

Task 2 Report:

Title 27 Effectiveness to Protect Groundwater Quality

Executive Summary

The purpose of this report is to evaluate the effectiveness of California Code of Regulations (CCR) Title 27 requirements intended to protect groundwater quality from confined animal facility waste discharges. Pursuant to Title 27 §22560, the purpose of the regulations is to set minimum standards for the discharge of animal wastes and to specify the general information that should be submitted to the Regional Water Quality Control Board (RWQCB) by a discharger subject to the requirements. The RWQCB, in turn, relies on these minimum standards and the submitted information to evaluate the nature and possible water quality consequences of the discharge and to prescribe Waste Discharge Requirements (WDRs) for the discharger. The California Water Code (CWC) §13263 requires that the WDRs implement state and federal water quality control policies (such as the State's Antidegradation Policy) as well as the applicable regional water quality control plan (Basin Plan) standards for the facility.

Confined animal facility operations typically concentrate animals in feeding areas, milk production areas, and within open corrals. Wastes from the operations include manure, bedding, hair, spilled feed, and leachate from silage. The composition of animal manure depends on a number of factors such as the animal species, size, maturity, health, and composition of animal feed. Generally, the primary pollutants associated with animal wastes with potential to affect groundwater include nitrogen compounds, salts, organic matter, pathogens, and to a lesser extent, antibiotics, pesticides, and hormones. Both wet and dry systems are used to manage these wastes. In many instances, animal wastes from feeding and milk production areas are flushed with water to sumps that separate solids and direct the waste slurry to a system of wastewater retention ponds. Dry management systems such as tractor or chain-pull scrapers are used by some operations to manage wastes from feeding areas and corrals.

The potential for nitrogen compounds affecting groundwater quality is recognized by a 1998 United States Geologic Survey (USGS) report that notes median nitrate concentrations in shallow groundwater wells in the San Joaquin Valley have increased significantly since the 1950s. During this time, the number of confined animal facilities (particularly dairies) has increased in the Central Valley and the USGS states that confined animal facility waste is one source of the relatively higher nitrate concentrations (nitrogen fertilizer used for agriculture is the other identified source). These findings are corroborated by site-specific data and published information that indicate groundwater quality has been affected at a



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number of Central Valley dairy facilities, some of which are known to be in compliance with current minimum standards for the management of confined animal wastes.

The minimum standards for confined animal facilities specified in Title 27 provide limited siting, design, and construction requirements designed to protect groundwater quality at confined animal facilities. This is in marked contrast to the extensive minimum standards for groundwater quality protection that are included for other waste disposal facilities that are regulated by Title 27. For example:

- **Title 27 Operations Requirements.** Title 27 requires that manured areas be managed to “minimize” infiltration of water into the underlying soils. Without setting an appropriate, quantifiable standard and without consideration of site-specific subsurface conditions, however, these requirements provide no assurance that groundwater will not be affected above regulatory limits by infiltration from manured areas such as corrals. This conclusion is supported by site-specific Central Valley data that show high levels of pollutants consistent with animal wastes in the soil and groundwater below corral areas.
- **Title 27 Retention Pond Design Requirements.** Title 27 requires only that retention ponds be lined with, or underlain by, soils that contain at least 10 percent clay and not more than 10 percent gravel (Title 27 does not include any permeability requirements for retention ponds). The hydraulic conductivity of soils that meet these criteria easily could range over several orders of magnitude and could be as high as 10^{-3} cm/sec or greater. Consistent with this finding, the Natural Resource Conservation Service (NRCS) guidance notes that soils with less than 20 percent clay have the “highest permeability and could allow unacceptably high seepage losses.” Additionally, Title 27 provides no groundwater separation standards or pond containment thickness, uniformity, or construction quality assurance requirements. As a result, there is no assurance that facilities meeting the Title 27 requirement of 10 percent clay will effectively limit seepage from the retention ponds and be protective of groundwater. This conclusion is supported by data which indicates that animal wastes may have affected the groundwater below several Central Valley dairy facility retention ponds that meet the Title 27 liner requirement. Other published studies document that groundwater contamination has been associated with leakage from animal waste retention ponds constructed to Natural Resource Conservation Service (NRCS) standards that are more stringent than the current Title 27 requirements.
- **Site Specific Conditions.** The potential for and the magnitude of confined animal facility waste impacts to groundwater are largely dependent on the nature of the subsurface conditions at a particular facility. In general, for cases where the facility is located in a stable area, is underlain by fine-grained soils, and groundwater occurs at depth, the potential for groundwater degradation can be relatively low over the short term. Conversely, groundwater could be degraded relatively rapidly for a facility underlain by coarse-grained soils, fractured bedrock, and/or shallow groundwater. In most cases, a number of different subsurface considerations and the factor of time must be weighed

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together and best professional judgment is necessary to assess the sensitivity of groundwater contamination for a given area. The importance of subsurface conditions is confirmed by data from published studies that demonstrates the need for detailed siting, design, and construction guidelines that recognize the differences in the performance potential of various soils and geologic materials. However, Title 27 does not require consideration of subsurface geologic conditions or the depth to groundwater in the siting, design, construction, or operation of confined animal facilities or waste management systems.

- **Title 27 Information Requirements.** Title 27 regulations require submittal of a Report of Waste Discharge (ROWD) that includes general information regarding the average daily volume of facility wastewater and volume or weight of manure; total animal population at the facility and types of animals; the location and size of use or disposal fields and retention ponds; and the animal capacity of the facility. However, Title 27 does not require that the ROWD address or otherwise consider site-specific geologic conditions important to groundwater protection.

Based on these considerations, in addition to site-specific data from Central Valley dairies, and the information included in published studies, it is reasonable to conclude that current Title 27 requirements are insufficient to prevent groundwater contamination from confined animal facilities, particularly in vulnerable geologic environments,. (For the purposes of this study, “vulnerable” geologic environments typically include, but are not limited to, areas where subsurface materials underlying the facility are relatively coarse-grained, where groundwater occurs at shallow depth, where contaminants may impact groundwater over time, or where other geologically unsuitable conditions are present.) Moreover, because Title 27 does not require that site-specific information be submitted to the RWQCB as part of a ROWD, it follows that the RWQCB cannot reliably evaluate the nature and possible water quality consequences of animal waste discharges, and therefore cannot rationally implement the applicable Basin Plan and the State’s Antidegradation Policy requirements. However, the RWQCB can request additional information to be submitted.



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Section 1

Introduction

The Central Valley RWQCB (CVRWQCB) reports there are approximately 2,000 confined animal facilities in the Central Valley Region of California, of which about 1,700 are dairies (approximately 80 percent of California dairies are located in the Central Valley). Of the remaining 300 operations, approximately 200 are poultry facilities and the rest include feedlot, horse, goat, sheep, swine, and llama facilities (CVRWQCB 2002b).

In the Central Valley, Stanislaus, Merced, and Tulare Counties have the largest number of dairies, with approximately 300 operating in each county. As a result of the number and size of its dairies, Tulare County is the top milk-producing county in America. San Joaquin, Fresno, and Kings Counties each have between 100 and 200 dairies. The remaining counties each have fewer than 100 dairies although some, such as Kern County, have some of the largest facilities. The majority of the poultry industry consists of chicken and turkey meat, and egg production, with the top five producers in 2000 being Fresno, Merced, Stanislaus, Riverside, and Tulare Counties (CVRWQCB 2002b).

Predominant confined animal facility waste constituents that have the potential for adverse environmental and human health effects when in contact with groundwater include nitrogen (in its various forms), salts (including phosphorus and potassium), pathogens, and to a lesser extent, antibiotics, pesticides, and hormones. These wastes, if improperly managed, can lead to nuisance conditions and/or discharge to surface water or groundwater. This may be of particular concern in the Central Valley because much of the water used for domestic purposes comes from groundwater sources (Dubrovsky et al. 1998).

According to the U.S. Environmental Protection Agency (U.S. EPA), the premise that shallow groundwater can become contaminated with manure pollutants from water traveling through the soil to the groundwater is well established (U.S. EPA 2003). This finding is supported by the analysis of several thousand groundwater samples that were compiled from USGS and U.S. EPA databases to evaluate the long-term changes in nitrate concentrations in the San Joaquin Valley of California. Data from wells in the eastern San Joaquin Valley that are less than or equal to 200 feet deep indicates median nitrate concentrations increased significantly from the 1950s to the 1960s and from the 1970s to the 1980s (Dubrovsky et al. 1998). Although the amount of nitrogen fertilizer applied in the eastern San Joaquin Valley counties increased during this time, Dubrovsky et al. observed that the number of dairies and other confined animal facilities, and hence manure production, increased greatly as well. They further indicated that nitrogen fertilizer is the largest source of nitrate in the eastern San Joaquin Valley, although this generalization may not be the case for areas where the source may be attributed to confined animal facilities located close together.



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In the Central Valley, the CVRWQCB regulates confined animal facilities under Title 27. Title 27 was adopted by the State Water Resources Control Board (SWRCB) pursuant to CWC §13172. Title 27 contains minimum standards for confined animal facilities, but also allows the RWQCB to impose additional requirements if necessary to prevent degradation of water quality or impairment of beneficial uses of state waters. In addition to Title 27, and as required by CWC §13263, the RWQCB implements and applies the applicable Basin Plan and the State's Antidegradation Policy.

Historically, most confined animal facilities have operated under a waiver of WDRs with the condition of the waiver being compliance with the minimum standards now included in Title 27. Prior to 1999, the CVRWQCB appears to have accepted either; (i) that compliance with the minimum standards of Title 27 would be sufficient to prevent degradation of groundwater, or (ii) that these minimum standards represented the best practicable management practices for protection of waters of the State. In 1999, however, the State Legislature changed the CWC to require review of all waivers prior to January 1, 2000 and each five years thereafter. During its review of the waiver program, the CVRWQCB raised issues regarding the adequacy of Title 27 to protect groundwater at confined animal facilities. Independent of the CVRWQCB review, a number of counties in California have prepared (or are in process of preparing) ordinances or general plan revisions that address the potential environmental impacts of confined animal facilities. In particular, Merced and Kings Counties have adopted much stricter requirements for confined animal facilities than the Title 27 requirements. Some states have also adopted strict requirements for confined animal facilities. The evaluation of the other states' requirements will be examined in a subsequent report.

1.1 Purpose and Scope of Report

1.1.1 Purpose

The purpose of this task report is to evaluate the effectiveness of current Title 27 requirements in protecting groundwater quality in the Central Valley from possible discharges from retention ponds, milk production areas, and corrals at confined animal facilities. For the purposes of this and subsequent task reports, retention ponds include any confined animal facility pond constructed for the purpose of storing wastewater or settling solids from the wastewater. Milk production areas include areas of a confined animal facility used as milking parlors, cow wash areas, and flush alleys. Corrals include any areas of a confined animal facility that are used as barns, stalls, free stalls, feedlots, manure storage areas, or composting areas, and any other areas where animals are confined.

1.1.2 Approach and Scope of Work

The approach taken to meet the project objective included a review of the purpose and factual basis for the existing Title 27 regulations, evaluation of the type of wastes associated with confined animal facilities, identification of potential pathways to the groundwater and

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potential environmental or human health impacts associated with these wastes, identification of natural factors important to groundwater protection, and evaluation of Title 27's effectiveness toward identifying and mitigating conditions that may render an area susceptible to groundwater impacts. Concurrent with this evaluation, data was reviewed to identify and evaluate known impacts to groundwater associated with confined animal facilities. This information was then used to develop conclusions regarding Title 27's effectiveness in protecting groundwater quality.

The specific scope of work performed for this task was based on information provided by the CVRWQCB and other published data, and included:

- A review of the Statement of Reasons and factual basis for the existing Title 27 regulations.
- A review of published and unpublished data regarding confined animal facility operations, wastes, and waste management practices.
- A site visit to an operating dairy in the Central Valley to observe typical facility conditions and waste management practices.
- A review of information regarding confined animal facility impacts on water quality.
- A review of Central Valley confined animal facility-specific groundwater data.
- An evaluation of data limitations associated with potential impacts to groundwater resultant of releases from confined animal facilities.
- Recommendations for additional studies to address areas where data is limited or deficient.
- Preparation of this task report.

The scope of work for this report did not include an evaluation of other federal, state, or local governmental regulations or guidelines that may pertain to groundwater quality protection at confined animal facilities, nor did it include an evaluation of possible alternative criteria to protect groundwater from retention ponds releases, milk production areas, and/or corrals. These evaluations and recommendations will be included in subsequent reports.



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Section 2

Existing California Regulations

2.1 Regulatory Authority

California's primary water quality control law is the Porter-Cologne Water Quality Control Act (Porter-Cologne Act). The Porter-Cologne Act authorizes the regulation of discharges of waste in order to attain the following legislative objectives expressed in §13000 of the CWC:

"The Legislature finds and declares that the people of the state have a primary interest in the conservation, control, and utilization of the water resources of the state, and that the quality of all waters of the state shall be protected for use and enjoyment by the people of the state."

"The Legislature further finds and declares that activities and factors which may affect the quality of the waters of the state shall be regulated to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible."

The Porter Cologne Act's objective to protect surface water and groundwater quality is implemented through the CCR and the issuance of WDRs. The SWRCB and its nine RWQCBs are the primary agencies that issue WDRs and regulate confined animal facilities through the authority of the Porter-Cologne Act and §22560 through 22565 of CCR Title 27.

In accordance with CWC §13260, any person discharging or proposing to discharge wastes that could affect the quality of surface or groundwaters is required to file a report of waste discharge with the appropriate RWQCB. The RWQCB uses this information to evaluate the nature of possible water quality consequences of the discharge and to prescribe WDRs. CWC §13263 requires that these WDRs implement both state and federal water quality control policies as well as Basin Plans.

The CVRWQCB regulates 57 of the approximately 1,700 Central Valley dairies under General WDR 96-270. This WDR established provisions to protect water quality from confined animal facility discharges that include preparation of a Water Pollution Prevention Plan (WPPP), inspections, a Nutrient and Irrigation Water Management Plan, and annual reporting. Prior to January 1, 2003, a waiver from WDRs could be obtained when the discharger complied with RWQCB guidelines and most facilities held these waivers.¹ The RWQCB also regulates some dairies under individual WDRs depending on site-specific conditions.

¹The Waiver Program allowed dairies to operate if they complied with the Board's minimum guidelines, which were later incorporated into the CCR. Pursuant to recent legislation, the Waiver Program was terminated January 1, 2003.



2.2 Basin Plan and the State's Antidegradation Policy

In addition to WDRs, the Porter-Cologne Act requires each RWQCB to establish Basin Plans, and within the CVRWQCB region, these Plans have been established for the San Joaquin and Sacramento River Basins and for the Tulare Lake Basin. The Plans specify water quality objectives to protect the beneficial uses of surface water and groundwater and include an implementation program to achieve the water quality objectives. The Basin Plans for the Sacramento and San Joaquin River Basins and for the Tulare Lake Basin specifically include confined animal operations as one of the water quality concerns for the basins and state that runoff from these facilities can impair the beneficial uses of both surface water and groundwater (CVRWQCB 1995; 1998b; 2002a). The Tulare Lake Basin Plan also includes the additional requirement that new retention ponds be sited, designed, constructed, and operated to ensure that the bottom of the pond is at least five feet above the highest anticipated groundwater elevation (CVRWQCB 1995; 2002a).

The State's Antidegradation Policy (SWRCB Resolution 68-16) is incorporated into these Basin Plans and declares it is the policy of the State that granting of permits for waste disposal shall be regulated as to achieve the highest water quality consistent with maximum benefit to the people of the State. The Antidegradation Policy serves as the foundation for regulatory actions and includes the following specific policies (Dunham and Walker 2003):

- Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies.
- Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained.

The Basin Plans require the Regional Board to implement the State's Antidegradation Policy when issuing a permit. Under this requirement, a ROWD must include information regarding the nature and extent of the discharge and the potential for the discharge to affect surface or groundwater quality in the region.

2.3 CCR Title 27 Minimum Standards

Specific CCR Title 27 requirements that pertain to confined animal facilities are included in Appendix A. As shown in this appendix, principal Title 27 minimum standards include:

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- **§22560 - Applicability.** The specific purpose of this section is to explain that the scope of the regulation is to set forth minimum standards for discharges of animal wastes and to describe what general information should be submitted by a discharger subject to the regulations. This section describes the application of minimum standards for discharges of animal waste at confined animal facilities and requires the discharger to submit a ROWD that provides information identifying the average daily volume of wastewater generated and volume or weight of manure, total animal population and types of animals, location and size or use of disposal fields and retention ponds, and animal capacity of the facility.
- **§22561 - General Standard for Surface Water.** The specific purpose of this regulation is to describe general standards for confined animal facilities. This section requires that the discharger prevent animals at confined animal facilities from entering any surface water within the confined area.
- **§22562 - Wastewater Management.** The specific purpose of this regulation is to describe requirements for facilities relative to the handling of wastewater and the control of precipitation and drainage with the goal of reducing infiltration. This section provides the minimum standards for wastewater management and includes design storm criteria for run-on and runoff control and flood protection, retention pond design, and discharge to disposal or use fields. Section 22562 also contains an exclusion for manured area run-on.
- **§22563 - Use or Disposal Field Management.** The specific purpose of this regulation is to describe the performance standards for managing disposal fields to preclude degradation of ground or surface waters. This section requires that application of manure and wastewater to disposal fields or croplands be at rates which are reasonable for the crop, soil, climate, special local situations, management system, and type of manure. Section 22563 also requires that discharge to disposal fields be managed to minimize percolation to groundwater.
- **§22564 - Management of Manured Areas.** The specific purpose of this section is to specify performance standards for the management of manured areas. In accordance with this section, manured areas must be managed to minimize infiltration of water into the underlying soils.
- **§22565 - Monitoring.** The specific purpose of this section is to indicate that monitoring of surface or groundwater may be required at confined animal facilities to determine if waste is entering the ground or surface water. This section allows the RWQCB to require a monitoring program as a condition to the issuance or waiver of WDRs.

It is noted that the purposes of these sections are also provided in the “Statement of Reasons” for Subchapter 15 (now Title 27) of the CCR (See Appendix A).



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Section 3

Overview of Confined Animal Facilities

3.1 Confined Animal Manure Management and Waste Handling Processes

Waste handling and manure management practices at confined animal facilities are closely tied to animal housing practices. In general, large beef feedlots, dairies, and heifer operations have large outdoor confinement areas where animals are housed for all or at least a portion of the time. Because these facilities are outdoors, their waste management practices are affected by climate and must account for precipitation. In contrast, nearly all large swine, poultry, and veal calf operations use total confinement housing that prevents contact of runoff and precipitation with the animals and manure. The following sections describe the general manure management and waste handling processes as summarized in the document used by the U.S. EPA to support the new federal confined animal facility requirements (U.S. EPA 2002). The document is included in Appendix B.

3.1.1 Beef Feedlots

The majority of large beef feedlots are open and usually unpaved. In general, these open lots expose large surface areas to precipitation, thereby generating large volumes of storm water contaminated with manure, bedding, feed, silage, and other process contaminants. These types of operations may use mounds in the pens to improve drainage and provide areas that dry quickly. (Dry resting areas improve cattle comfort, health, and feed utilization, all of which contribute to efficient animal weight gain.) The animals are fed two or three times per day, and a concrete apron is typically located along the heavily trafficked feed bunkers and water troughs.

Unroofed confinement areas typically have a storage system for collecting and confining contaminated runoff. The runoff is usually directed to a storage pond, and the manure from open lots is often scraped and stacked into mounds or stockpiles. Beef feedlots typically use a settling basin to remove bulk solids from the liquid waste stream, thereby reducing the volume of solids before the stream enters the storage pond.

3.1.2 Dairies

The primary function of a dairy is the production of milk, which requires a herd of mature dairy cows that are lactating. In order to produce milk, the cows must be bred and give birth. Accordingly, a dairy operation may have several types of animal groups present, including calves, heifers, cows that are close to calving, lactating dairy cows, dry cows, and bulls. Wastes associated with dairy production include manure, contaminated runoff, milking parlor waste, bedding, spilled feed, and leachate from feed storage areas.



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Animals at dairy operations may be confined in a combination of free stall barns, outdoor dry lots, tie stalls, or loose housing (barns, shades, and corrals). Some animals may be allowed access to exercise yards or open pastures. At dairies, the most common types of housing for lactating cows include free stalls, dry lots, tie stalls/stanchions, pastures, or a combination of these. (Free stalls are the most commonly used housing system.) The cows are not restrained in the free stalls and are allowed to roam on concrete alleys to the feeding and watering areas. Manure collects in the travel alleys and is typically removed with a tractor or mechanical alley-scraper, by flushing with water, or through slotted openings in the floor.

Dry lots are outside pens that allow the animals some exercise, but do not generally allow them to graze. In general, the open lots expose large surface areas to precipitation and may generate large volumes of contaminated storm water. The milking parlor is typically cleaned several times each day to remove manure and dirt via flushing or hosing and scraping.

Most dairies have both wet and dry waste management systems. The dry waste (manure, bedding, and spilled feed) is typically collected from the housing and exercise areas by tractor scrapers and stored where an appreciable amount of rainfall or runoff does not come into contact with the waste. The wet waste (water from the barn and milking parlor cleaning operations, manure, and contaminated runoff) is typically stored in retention ponds.

Similar to beef feedlots, dairies often use solid separators to remove bulk solids from a liquid waste stream. The wastewater that accumulates in the storage lagoons is typically used for fertilization of cropland. The cropland where the wastewater is applied may be part of the parcel where the dairy is located. In some instances, the cropland where the wastewater or manure is applied may not be contiguous with the dairy and may be under different ownership.

3.1.3 Swine, Poultry, and Veal Calf Facilities

In contrast to beef feedlots and dairies, nearly all large swine, poultry, and veal calf operations use total confinement housing. These confinement buildings prevent contact of storm water runoff and precipitation with the animals and manure. Moreover, these operations are able to manage manure in a relatively dry form or contain liquid wastes in storage structures such as lagoons, tanks, or under-house pits that are not greatly affected by precipitation.

Most swine facilities raise pigs in pens or stalls in environmentally controlled confinement housing. These houses commonly use slatted floors to separate manure and wastes from the animal. Swine wastes include manure, spilled feed, and water used to clean the housing area or dilute the manure for pumping. The flushed manure is usually stored in anaerobic lagoons or tanks, while deep pit systems are frequently used to store manure under the confinement houses.

Poultry operations are generally classified into operations that breed or raise broilers, breed or raise hens that lay shell eggs (layers), or egg production facilities that house laying hens.

These types of operations use total confinement housing; broilers are raised on beds of litter shavings, sawdust, or peanut hulls, and laying poultry are confined to cages which are suspended over a bottom story, pit, belt, or scraper gutter. The majority of poultry operations use dry manure handling, although some egg-laying facilities use liquid systems that flush waste to a lagoon. Typical poultry wastes include manure, poultry mortalities, litter, spilled water and feed, egg wash water, and flush water at operations with liquid manure systems. Manure is usually allowed to accumulate on the floor, where it is mixed with the litter. The removed litter is stored in temporary field stacks, covered piles, or stacks within a roofed facility to help keep it dry.

Veal calf operations are usually performed in confined housing using individual stalls or pens. Floors are constructed of either wood slats or plastic-coated expanded metal to allow for efficient removal of waste. Veal calf waste consists of manure, flushing water, and spilled liquid feed. (Veal calves are raised on a liquid diet, and their manure is highly liquid.) Manure is typically removed from the housing facilities by scraping or flushing from collection channels; then it is flushed or pumped into liquid waste storage structures, ponds, or lagoons.

3.2 Typical Confined Animal Waste Management System Components

3.2.1 Water Conveyance Systems

Process water is used for a variety of operations and waste management purposes at confined animal facilities. For example, dairies use water for cleaning in the milking parlors, where the cows are washed down prior to milking. Generally, the milking parlor has a concrete floor, and the wastewater from this operation is routed to a retention pond. Dairies and feedlots also commonly use flush alleys in feeding areas and corrals as a transport system to carry animal waste and wastewater to retention ponds. Although most poultry operations utilize dry waste management systems, some egg-producing poultry facilities have a flush system to transport manure from under the cages to a retention pond.

3.2.2 Dry Waste Management Systems

Corrals have been broadly defined in this report to include barns, stalls, free stalls, feedlots, manure storage areas, composting areas, and any other area where animals are confined. Outside of flush alleys, most operators typically use dry manure management systems, such as shoveling and mechanical scrapers for these areas. The dry manure is commonly stockpiled on site and reused. To minimize the spread of disease, most confined poultry facilities also use a dry management system whereby manure is removed by mechanical methods and transported offsite.



3.2.3 Retention Ponds

Retention ponds are frequently used at confined animal facilities to store process wastewater, precipitation, and drainage that are collected from manured areas. In most cases, wastewater is processed first through a settling pond, where the manure solids settle by gravity. Some facilities also use mechanical separators to enhance solids removal from the settling pond. The liquid in the upper portion of the settling pond is then transferred to the wastewater retention pond. Despite this settling and/or mechanical removal process, retention pond wastewaters typically contain some solids. For example, Van Horn et al. (1998) indicate gravity separation in retention ponds typically removes about 40 to 60 percent of total solids. Little data is currently available to assess the efficiency of mechanical separators in removing solids compared with solids removal solely by settling ponds, although Van Horn et al. (1998) indicate stationary screen separators remove about 20 percent of the organic matter from flushed dairy manure. Broiler poultry facilities commonly use water retention ponds to receive incidental wastes that may result from transporting birds between trucks and the houses or from the manure loading area. The water in these retention ponds is typically allowed to evaporate during the summer months.

3.3 Confined Animal Facility Pollutant Source Areas

Hydrologically, confined animal facilities represent a complex system with multiple potential sources for pollutant migration or leaching to the groundwater. Principal source areas include, but are not limited to, milk parlors, retention ponds, corral areas, and land areas where manure or process wastewater may be applied. Corrals and dry manure storage areas represent potential threats resulting from waste constituents leaching into the soil and groundwater because of the large quantities of manure generated by confined animals and because of the relatively high concentration of waste constituents present in manure (see Table 3-1). Corral areas may represent a particular threat because these areas are frequently open and exposed to precipitation.

The dissolved constituents in the retention ponds represent a potential threat to subsurface soil and groundwater quality because of the relatively high concentrations of waste constituents present (see Table 3-2) and because the retention ponds are often constructed without engineered clay or synthetic liners. As described in Section 4.1.2, the potential threat from these ponds may be mitigated to a certain degree because the base of retention ponds may “self-seal” due to solids settling out of solution and the accumulation of anaerobic byproducts that accumulate at the soil-liquid interface.

Regardless of source area, the potential for waste constituent migration from confined animal facilities affecting groundwater is influenced by site-specific subsurface conditions. For example, shallow groundwater conditions² may render an area sensitive to groundwater

² The term “shallow” is subjective and depends on the context of the evaluation being performed, the nature of the subsurface conditions, and other factors that are usually interrelated. As an example, the USGS (Dubrovsky et al. 1998) consider wells that are completed within 200 feet of the ground

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contamination because infiltrating wastewater has a short travel distance and a shorter soil column is available to attenuate waste constituent concentrations. Similarly, high soil hydraulic conductivity may also render an area sensitive to groundwater contamination because the relatively higher wastewater infiltration rates can lead to fairly rapid migration to groundwater. Generally, however, a number of subsurface factors must be considered together and best professional judgment is necessary to assess the sensitivity of groundwater contamination for a given area. For example, an area of shallow groundwater but relatively impermeable soil may not have a high sensitivity to groundwater contamination in the short term. In the same way, an area with highly permeable soil but very deep groundwater may also have a low sensitivity contamination. However, the factor of time must also be considered as fine-grained soils and/or deep groundwater may only slow the migration of contaminants to the groundwater. As described in more detail in Section 4, other geologic factors important to the potential migration of contaminants to the groundwater include among others, unstable ground, faulting, and slope instability.

surface as shallow. For comparison, groundwater beneath many dairies in the Central Valley, at least seasonally, is less than 5 feet below the ground surface.



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TABLE 3-1
Typical Fresh Dairy Manure Characteristics
Per 1,000 Pounds Live Weight Per Day

PARAMETER	MEAN VALUE (Mature Dairy Cow)			
	ASAE	USDA	NCSU	MWPS
Moisture (%)	87.2	87.5	ND	87.3
Total Solids (lb)	12	10	12.1	12
Volatile Solids (lb)	10	8.5	10	10
BOD (lb)	1.6	1.6	1.82	1.6
COD (lb)	11	8.9	11.17	ND
pH	7	ND	7	ND
TKN (lb)	0.45	0.45	0.45	0.43
Ammonium-N (lb)	0.079	ND	0.84	ND
Total P (lb)	0.094	0.07	0.22	0.17
Orthophosphorus (lb)	0.061	ND	0.14	ND
Potassium (lb)	0.29	0.26	0.36	0.34
Calcium (lb)	0.16	ND	0.17	ND
Magnesium (lb)	0.071	ND	0.075	ND
Sulfur (lb)	0.051	ND	0.052	ND
Sodium (lb)	0.052	ND	0.064	ND
Chloride (lb)	0.13	ND	0.13	ND
Iron (lb)	0.012	ND	0.012	ND
Manganese (lb)	0.0019	ND	0.0019	ND
Boron (lb)	0.00071	ND	0.00073	ND
Molybdenum (lb)	0.000074	ND	0.000075	ND
Zinc (lb)	0.0018	ND	0.0019	ND
Copper (lb)	0.00045	ND	0.00047	ND
Cadmium (lb)	0	ND	0	ND
Nickel (lb)	0.0003	ND	0.00028	ND
Total Coliform Bacteria (colonies)	500	ND	1.09E11 (colonies/100g)	ND
Fecal Coliform Bacteria (colonies)	7.2	ND	7.45E10 (colonies/100g)	ND
Fecal Streptococcus Bacteria (colonies)	42	ND	4.77E11 (colonies/100g)	ND
NOTES:				
1. All data from EPA (2003). See Appendix B.				
2. ASAE – American Society of Agricultural Engineers.				
3. USDA – U.S. Department of Agriculture.				
4. NCSU – North Carolina State University.				
5. MWPS – Midwest Planning Service.				
6. BOD – 5 Day Biochemical Oxygen Demand.				
7. COD – Chemical Oxygen Demand.				
8. TKN – Total Kjeldahl Nitrogen.				
9. ND – No Data.				

TABLE 3-2
Dairy Waste Characterization
Lagoons

COMPONENT	UNITS	LAGOON (USDA Data/NCSU Data)		
		Anaerobic Supernatant	Anaerobic Sludge	Aerobic Supernatant
Moisture	%	99.75/ND	90/ND	99.95/ND
Total Solids	% wet basis	0.25/0.87	10/7.2	0.05/ND
Volatile Solids	lb/1,000 gal	9.16/52.4% dry basis	383.18/56.7% dry basis	1.67/ND
Fixed Solids	lb/1,000 gal	11.66/ND	449.82/ND	2.5/ND
COD	lb/1,000 gal	12.5/36.69	433.16/260.6	1.25/ND
BOD	lb/1,000 gal	2.92/7.8	ND	0.29/ND
N	lb/1,000 gal	1.67/4.86	20.83/19.16	0.17/ND
NH ₄ -N	lb/1,000 gal	1.0/ND	4.17/ND	0.1/ND
P	lb/1,000 gal	0.48/2.76	9.16/41.8	0.08/ND
K	lb/1,000 gal	4.17/6.5	12.5/9.2	ND
C:N ratio	unitless	3/ND	10/ND	ND
Copper	lb/1,000 gal	ND/0.009	ND/0.46	ND
Zinc	lb/1,000 gal	ND/0.051	ND/0.74	ND
NOTES: 1. All data from EPA (2003). See Appendix B. 2. USDA – U.S. Department of Agriculture. 3. NCSU – North Carolina State University. 4. ND – No Data.				

3.4 Animal Waste Constituents with the Potential to Pollute Groundwater

3.4.1 General

The primary pollutants to groundwater associated with animal wastes include nitrogen compounds, salts, organic matter, pathogens, and to a lesser extent, antibiotics, pesticides, and hormones. The composition of manure at a particular confined animal facility depends on a number of factors such as the animal species, size, maturity, health, and the composition of animal feed. Detailed information regarding the amount and characteristics of wastes associated with different confined animal facilities is included in Appendix B. Because dairies represent the majority of confined animal facilities in the Central Valley, information regarding typical dairy waste constituents and concentrations is presented in Tables 3-1, 3-2, and 3-3 for fresh manure, wastes in lagoons, and wastes from milking centers. Summary information regarding the principal waste constituents important to groundwater quality protection is presented below.

3.4.2 Nitrogen

Nitrogen may be the most significant constituent of dairy waste. This is due to the relatively high concentration of nitrogen in manure, its economic value if harvested and applied to crops as fertilizer, and its potential as a pollutant in soil, air, and groundwater. Nitrogen is



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excreted in relatively large amounts by dairy cows, at a rate of at least 0.45 pounds of nitrogen per animal unit per day (Merced County 2002).³ Recent work by the University of California Dairy Wastes Committee of Consultants indicates that nitrogen excretion by dairy cows may be up to two and a half times higher than earlier estimates (182g cow⁻¹ day⁻¹ (0.45 pounds) estimated in 1973 versus an average of 462g cow⁻¹ day⁻¹ (1.14 pounds) estimated in 2001 for a dairy cow). The difference in estimates results from an adoption of a more robust and reliable method to estimate the amount of nitrogen excreted by dairy cows (Chang 2002).

It is reported that manure water and wastewater in anaerobic storage ponds ranges from 200 to 1,000 mg/L total nitrogen, with one-third to two-thirds of the nitrogen as ammonia and the remainder in organic form (Harter et al. 2002). Nitrogen is present in soils as organic nitrogen, ammonium (NH₄⁺), and nitrate (NO₃). In unpolluted surface water and groundwater, only trace levels of nitrate are found (typically less than 2 mg/L nitrate as nitrogen). Ammonia (NH₃) is a pungent-smelling volatile gas. When dissolved in water, ammonia forms ammonium (NH₄⁺), which is the predominant form of nitrogen in soils and wastewater from dairies. If ammonium is not volatilized from urine or manure, it can be adsorbed into soil and converted to nitrate under aerobic conditions in the soil. If the ammonium is converted to nitrate, its mobility in the subsurface increases and can result in nitrate migration to groundwater.

In the environment, nitrogen from dairy wastes can degrade surface water quality by supplying nutrients that stimulate aquatic plants, algae, and growth of microorganisms. Soil microorganisms, combined with algae and aquatic weed growth, can deplete the dissolved oxygen content of lakes and streams, reducing habitat quality through eutrophication. Beneficial uses of groundwater can be impaired if ammonium and/or organic nitrogen is converted to nitrate. In addition, the excess loading of ammonium to soils underneath lagoons can represent a long-term groundwater threat if the soil becomes aerated and ammonium is converted to nitrate.

3.4.3 Phosphorus

Unlike nitrogen, phosphorus is not volatilized, and mass balance studies commonly account for greater than 85 percent of the total phosphorus in feed, milk, and waste. As indicated in Table 3-1, estimates of phosphorus in fresh manure range from about 0.07 pounds to 0.22 pounds per animal unit per day. Approximately two-thirds of the total phosphorus present as inorganic phosphate, with the remaining phosphorus present as organic phosphorus (this includes the phosphate present in enzymes, DNA, and phytic acid [an organic phosphorus species present in grain] (Merced County 2002). Phosphorus in dairy waste may enter lakes and other surface waters, stimulating algae and other microbial activity, in turn consuming oxygen and reducing the quality of the habitat for fish and water clarity through

³ One animal unit equals one 1,000-pound animal. Since the typical Holstein cow weighs 1,400 pounds, it would equal 1.4 animal units.

eutrophication. In California, groundwater impacted by phosphorus is rare because it is strongly adsorbed by negatively charged soils. Phosphate is also removed from groundwater by precipitation reactions.

3.4.4 Total Dissolved Solids (TDS or Salts)

The salinity of animal manure is directly related to the presence of dissolved mineral salts. In particular, significant concentrations of soluble salts containing sodium and potassium remain from undigested feed that passes unabsorbed through animals. Other major constituents contributing to manure salinity are calcium, magnesium, chloride, sulfate, bicarbonate, carbonate, and nitrate. Table 3-1 (above) summarizes average concentrations of these constituents in fresh dairy manure and Tables 3-2 (above) and Table 3-3 (below) summarize the average concentrations of the major salt constituents in waste retention ponds and in milking center waste. Table 3-3 specifically focuses on evaluating milk rooms, milk parlors, holding areas (retention ponds) and combinations of these elements under different circumstances. There is little data currently available regarding how much salt may be removed by the various solid separators that may be used at a particular dairy. It is reported that manure water and wastewater in anaerobic storage ponds contains from 2,000 to 4,500 mg/L total salts (Harter et al. 2002).

Salts are of concern because salt buildup may deteriorate soil structure, reduce hydraulic conductivity, contaminate groundwater, and reduce crop yields. Salts may also contribute to degradation of drinking-water supplies. The Tulare Lake Basin Plan identifies the increased salinity of groundwater as the greatest long-term problem facing the basin. The Basin Plan for the Sacramento and San Joaquin River Basins also notes that salt management is becoming important in the San Joaquin Valley and that if current practices for discharging wastes continue unabated, a large portion of the valley may have a sizeable portion of its groundwater degraded within a few decades (CVRWQCB 1995; 1998d).



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TABLE 3-3
Summary Of Dairy Waste Characterization
Milking Centers

COMPONENT	UNITS	MILKING CENTER			
		Milk Room	Milk Room + Milk Parlor	Milk Room + Milk Parlor + Holding Area ^a	Milk Room + Milk Parlor + Holding Area ^b
Volume	ft ³ /day/1,000 lbs	0.22	0.6	1.4	1.6
Moisture	%	99.72	99.4	99.7	98.5
Total Solids	% wet basis	0.28	0.6	0.3	1.5
Volatile Solids	lb/1,000 gal	12.9	35	18.3	99.96
Fixed Solids	lb/1,000 gal	10.6	15	6.7	24.99
COD	lb/1,000 gal	25.3	41.7	ND	ND
BOD	lb/1,000 gal	ND	8.37	ND	ND
N	lb/1,000 gal	0.72	1.67	1	7.5
P	lb/1,000 gal	0.58	0.83	0.23	0.83
K	lb/1,000 gal	1.5	2.5	0.57	3.33
C:N ratio	unitless	10	12	10	7
NOTES: 1. All data from EPA (2003). See Appendix B. 2. ^a Holding area scraped and flushed – manure removed via solids separator. 3. ^b Holding area scraped and flushed – manure included. 4. ND – No Data.					

3.4.5 Pathogens

Pathogens are defined as disease-causing microorganisms. A subset of these microorganisms, including certain species of bacteria, viruses, and parasites, can cause sickness and disease in humans and are known as human pathogens. Livestock manure may contain a variety of microorganism species, some of which are human pathogens. Multiple species of pathogens can be transmitted directly from a host animal's manure to surface water, and pathogens already in surface water can increase in number because of loadings of animal manure nutrients and organic matter. More than 150 pathogens found in livestock manure are associated with risks to humans, including the six human pathogens that account for more than 90 percent of food and waterborne diseases in humans (U.S. EPA 2003). These organisms include: *Campylobacter* spp., *Salmonella* spp. (non-typhoid), *Listeria monocytogenes*, *Escherichia coli* 0157:H7, *Cryptosporidium parvum*, and *Giardia lamblia*. All of these organisms may be rapidly transmitted from one animal to another in confined animal facility settings.

An important feature relating to the potential for disease transmission for each of these organisms is the relatively low infectious dose in humans. The distances pathogens can travel in various hydrogeologic environments are not well understood and considerable ranges have been reported in literature (Merced County 2002). In general, however, pathogens could enter the groundwater system by infiltrating downward through the unsaturated zone and/or through poorly constructed water supply wells that are not properly sealed at the surface.

3.4.6 Antibiotics

Antibiotics are used in animal feeding operations and can be expected to appear in animal wastes. Antibiotics are used to treat illness and as feed additives to promote growth or improve feed conversion efficiency. Between 60 and 80 percent of all livestock and poultry receive antibiotics during their productive life span (U.S. EPA 2003). The primary mechanisms of elimination are in urine and bile, so essentially all of an antibiotic administered is eventually excreted, whether unchanged or in metabolite form. Little information is available regarding the concentrations of antibiotics in animal wastes or antibiotic fate and transport in the environment. One concern regarding the widespread existence of antibiotics in animal manure is the development of antibiotic-resistant pathogens. Use of antibiotics (especially broad-spectrum antibiotics) in raising animals is increasing. According to the U.S. EPA, this could be contributing to the emergence of more strains of antibiotic-resistant pathogens (U.S. EPA 2003).

3.4.7 Pesticides and Hormones

Pesticides are applied to livestock to suppress houseflies and other pests. There has been very little research on loss of pesticides in runoff from manured lands. However, a 1994 study, as indicated by the Program Environmental Impact Report for the Merced County Animal Confinement Ordinance Revision, showed that losses of cyromazine (used to control flies in poultry litter) in runoff increased with the rate of poultry manure and litter applied and the intensity of rainfall (Merced County 2002). Specific hormones are used to increase productivity in the beef and dairy industries, and several studies have shown that hormones are present in animal manures. Poultry manure has been shown to contain both estrogen and testosterone. Runoff from fields with land-applied manure has been reported to contain estrogens, estradiol, progesterone, and testosterone, as well as their synthetic counterparts (Merced County 2002). No documented evidence of groundwater impacts by hormones was found during the course of this task report.



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Section 4

Assessment of Title 27 Requirements

As defined by Title 27, a confined animal facility means any place where cattle, calves, sheep, swine, horses, mules, goats, fowl, or other domestic animals are corralled, penned, tethered, or otherwise enclosed or held and where feeding is by means other than grazing. Per Title 27, confined animal facilities are regulated regardless of the size of the operation, and Title 27 does not differentiate between the different types of facilities that may be in operation.

4.1 Title 27 Groundwater Protection Requirements

4.1.1 Management of Manured Areas

Title 27 specifies that manured areas must be managed to minimize infiltration of water into the underlying soils. However, it provides no guidance or definition regarding “minimization.” This distinction is important because infiltration from manured areas could be minimized but groundwater quality could still be affected in geologic environments that do not limit migration and/or attenuate contaminants in the subsurface.

4.1.2 Design Requirements

The Statement of Reasons of Title 27 indicates: “Retention ponds shall be lined with or underlain by materials which reduce the infiltration of wastes to ground water. The clay and gravel percentages specified in subsection (f) of this section preclude the use of clayey gravel or other materials of relatively high permeability. The low permeability characteristics of the liner or natural materials are enhanced by a sealing effect from the manure placed in the retention ponds”⁴ (California EPA 1984). Assessment of the low permeability requirement and the sealing effect of manure is presented below.

Permeability of Liners or Natural Geologic Materials

Title 27 requires that retention ponds be lined with or underlain by soils that contain at least ten percent clay and not more than ten percent gravel. However, Title 27 does not include a maximum permeability requirement and there is no assurance that a soil containing ten percent clay will not have relatively high permeability. This is because soil permeability depends not only on grain size, but also on particle gradation, soil type, construction procedures, degree of saturation, and soil “defects” such as fissures or cracks (Mitchell 1992; Driscoll 1986; NRCS 1997). The potential range in soil permeability for soils that contain at least ten percent clay is illustrated by Bowles (1982) who indicates a range in permeability of about 10^{-3} cm/sec to 10^{-7} for soils classified as clayey sand. In accordance

⁴ The Statement of Reasons was prepared for CCR, Title 23, Chapter 3, Subchapter 15. The article regarding confined animal facilities was later moved to Title 27 without substantive changes.



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with the Unified Soil Classification System, clayey sands (SC) contain more than 12 percent clay. By way of comparison, NRCS (1997) guidelines indicate liners with a permeability of 10^{-6} cm/sec will result in acceptable seepage losses for most waste management structures. The significance of increased permeability is shown in Table 4-1 that indicates, *other factors being equal*, each order of magnitude increase in hydraulic conductivity will result in a tenfold increase in seepage and a tenfold increase in contaminant transport.

TABLE 4-1 Comparative Assessment Of Flux And Contaminant Loading At Base Of Liner Under Different Hydraulic Conductivity And Wastewater Depth Assumptions					
WASTEWATER DEPTH (Feet Above Liner)	LINER SATURATED HYDRAULIC CONDUCTIVITY (cm/sec)				
	1.00E-03	1.00E-04	1.00E-05	1.00E-06	1.00E-07
	Total Flux (gallons per acre per year)				
4	1,685,586,784	168,558,678	16,855,868	1,685,587	168,559
9	3,371,173,569	337,117,357	33,711,736	3,371,174	337,117
14	5,056,760,353	505,676,035	50,567,604	5,056,760	505,676
19	6,742,347,137	674,234,714	67,423,471	6,742,347	674,235
	Total Nitrogen (pounds per acre per year)				
4	7,692,958	769,296	76,930	7,693	769
9	15,385,916	1,538,592	153,859	15,386	1,539
14	23,078,875	2,307,887	230,789	23,079	2,308
19	30,771,833	3,077,183	307,718	30,772	3,077
	Total Salts (pounds per acre per year)				
4	41,670,190	4,167,019	416,702	41,670	4,167
9	83,340,381	8,334,038	833,404	83,340	8,334
14	125,010,571	12,501,057	1,250,106	125,010	12,501
19	166,680,762	16,668,076	1,666,808	166,680	16,668
NOTES: 1. Calculations assume steady-state flow and constant hydraulic conductivity through 1 ft thick soil liner. 2. Nitrogen loading based on average nitrogen wastewater concentration of 600 mg/L (midpoint of 200 mg/L to 1,000 mg/L range reported in the text for anaerobic retention ponds). Calculations assume no attenuation of nitrogen in the liner. 3. Salt loading based on an average total salt concentration of 3,250 mg/L (based on the 2,000 mg/L to 4,500 mg/L range reported in the text for anaerobic retention ponds). Calculations assume no attenuation of salts in the liner.					

The aforementioned information is consistent with NRCS (1997) guidance that indicates soils with less than 20 percent clay have the “highest permeability and could allow unacceptably high seepage losses.” NRCS also observes that permeability values for soils with less than 20 percent clay “may not be substantially reduced by manure sealing and will probably exceed 10^{-6} cm/sec.” Lastly, NRCS recommends that retention ponds underlain by soils with less than 20 percent clay be lined because coarse-grained soils with less than 20 percent low plasticity fines have the potential to allow rapid movement of polluted water and are also deficient in adsorptive properties because of their lack of clay.

In addition to variable hydraulic conductivity, the ten percent clay requirement is subject to differing interpretation and application, either of which could potentially lead to leakage and groundwater impairment. For example:

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- Title 27 does not have a thickness requirement for liner or subsurface materials that meet the ten percent clay requirement. As a result, an operator could rely on a very thin liner or subsurface layer that meets the ten percent requirement. Because flow and any associated contaminant transport through a liner or soil layer is proportional to the thickness of the liner or layer, a thin layer would transmit more water over a shorter period of time than would a thicker layer (other factors being equal).
- Title 27 does not require that the minimum ten percent clay be evenly distributed throughout the liner or subsurface soil layer. This is important because an improperly constructed liner could contain pockets of clay material sufficient to meet the Title 27 requirement, but still have a relatively high hydraulic conductivity. Similarly, it could be argued that natural subsurface soils with discontinuous clay layers meet the Title 27 ten percent clay requirement. However, if these layers were discontinuous, the effective hydraulic conductivity of the soil could be very high.
- Title 27 regulations for confined animal facilities do not have any requirement for construction quality assurance (CQA). As described in more detail in Section 4.3, CQA documentation and certification are required for other waste management facilities regulated under Title 27.

Sealing Effect of Manure Solids in Wastewater Ponds

It has been documented in the literature that natural soils on the boundaries of waste treatment lagoons and waste storage ponds partially seal as a result of introduction of manure solids into the pond (Chang et al. 1974; Meyer 1973). NRCS (1997) indicates the reduction in permeability from manure sealing may be one to three orders of magnitude. Sealing at the bottom of the ponds occurs because suspended solids settle out and physically clog the pores of the soil mass and anaerobic bacteria produce byproducts that accumulate at the soil-liquid interface and reinforce the seal. Meyer (1973) concluded that manure ponds seal under all soil conditions and that the time for sealing ranged less than 30 days for sandy loam, loams, and clay loams, and up to 60 days for loamy sands.⁵

Other studies contradict the premise that suspended solids and anaerobic bacteria form an effective long-term seal in retention ponds. For example, Chang et al. (1974) evaluated the impact of drying on the hydraulic conductivity of pond liners and concluded that drying of the pond bottoms occurs when the ponds are emptied, and this drying is likely to result in an increase in soil permeability to original values. Additionally, the shallow settling basins must be maintained on an annual or semiannual basis to remove solids that build up and reduce lagoon capacity. Maintenance activities are typically conducted with an excavator outside the lagoon or by bulldozers that drive into the lagoon, pushing solids into piles and

⁵ It is noted that such leakage, even though for a limited period of time, does not comply with the State's Antidegradation Policy. Additionally, recent groundwater studies in the Central Valley indicate some leakage appears to have occurred from ponds that were constructed to meet or exceed the Title 27 minimum standards (see Section 5).



transporting the piles out of the lagoon. Both types of maintenance activities have the potential to damage the base of the lagoon and decrease the effectiveness of any seal that may have formed. It is noted that the use of mechanical solid separators probably reduces the amount of settled solids in ponds and this reduction of solids and the associated reduction in anaerobic byproducts may limit the formation of a low-hydraulic conductivity seal (Chang et al. 1974).

The NRCS (1997) guidelines for animal facility pond liners have been developed under the premise that the hydraulic conductivity decrease induced by the manure should not be counted on as the sole means of groundwater protection, although the guidelines propose recognition of sealing to the extent of one order of magnitude. Under this premise, NRCS guidelines specify use of a liner material with a hydraulic conductivity of 10^{-6} cm/sec, which will result in a conservative effective hydraulic conductivity of 10^{-7} cm/sec after sealing. At least one study, as discussed in Section 5.2.5, has shown that lagoons constructed to NRCS standards may not prevent seepage in vulnerable geologic environments.

4.2 Consideration of Site-Specific Conditions

Current Title 27 requirements do not require any particular consideration or evaluation of site-specific geologic, hydrogeologic, or seismologic conditions with respect to siting, design, construction, operation, or monitoring of confined animal waste management facilities. This is significant because the nature of site-specific conditions play an essential role in groundwater quality protection as summarized below.

4.2.1 Geologic and Seismic Conditions

The Central Valley is a large, asymmetrical, northwest-trending structural trough that has been filled with up to six vertical miles of sediment in the San Joaquin Valley and ten vertical miles in the Sacramento Valley. These sediments range in age from Jurassic to Holocene and were derived from both marine and continental source areas. Granite and metamorphic rocks crop out along the eastern valley margin and underlie the sediments beneath the eastern side of the valley and marine rocks of pre-Tertiary age crop out along the western flank of the Central Valley. Although the Central Valley is considered relatively aseismic with respect to other areas of California, active faults are present along the eastern and western margins of the region, and its interior portions could experience strong ground shaking from a large earthquake on any of these faults.

Given the wide variety of geologic materials, characterization of the geologic setting of a particular facility is necessary to the assessment of potential risks to groundwater associated with confined animal facility wastes because differences in subsurface geologic conditions can result in significant differences in the relative risk of groundwater contamination from confined animal wastes. For example:

- The presence of coarse-grained soil may render an area sensitive to groundwater contamination because the relatively high hydraulic conductivity typically associated with

these materials can lead to rapid migration to groundwater. Conversely, the clay minerals associated with fine-grained deposits may provide appreciable attenuation of wastes in the subsurface, and the lower hydraulic conductivity of fine-grained soils can limit the rate of migration into the subsurface.

- Seismic activity could compromise the containment of animal waste management facilities through surface fault rupture or if strong ground shaking led to failure of a waste management structure. The intensity of ground shaking associated with an earthquake at any given site is dependent partly on the nature of subsurface conditions because some soil deposits attenuate (decrease) ground motion, while others may amplify the same motion. In the absence of appropriate design, significant levels of ground shaking could lead to the failure of retention structures.
- Loose, granular alluvial deposits below the water table may liquefy under the influence of an earthquake. Liquefaction occurring near the ground surface and in proximity to a retention pond could cause the pond to fail.
- Some locations in the western Central Valley are underlain by granular soils that are known to collapse in response to wetting. If these conditions are not identified and mitigated, collapse of such soils under a retention pond could lead to pond failure.

4.2.2 Hydrogeologic Conditions

In general, shallow groundwater conditions make an area relatively more sensitive to groundwater contamination than areas of deeper groundwater because infiltrating wastewater or waste constituents have a short travel distance to the groundwater and a shorter soil column to attenuate waste concentrations. Understanding seasonal groundwater level fluctuations and groundwater elevation changes in response to pumping is important to limit the potential for relatively high groundwater levels reaching the ground surface or intersecting with the bases of retention ponds that are excavated below grade. In addition, the characterization of shallow groundwater flow and nearby groundwater use(s) is important to any assessment of the relative risk associated with possible leakage from the facility and is critical to the design of any monitoring systems that may be required.

4.2.3 Significance of Subsurface Conditions with Respect to Title 27 and Groundwater Quality Protection

The potential for confined animal facilities waste affecting groundwater is at least partially dependent on the nature and characteristics of subsurface conditions. Because Title 27 requirements do not explicitly address these conditions and do not require that site-specific factors be addressed for confined animal facilities, the minimum standards contained in the regulation may or may not be protective of groundwater quality. For cases in which the facility is located in a stable area, is underlain by fine-grained soils, and groundwater occurs at great depth, the existing regulations may be adequate to minimize the potential for groundwater impacts. However, the existing regulations by themselves may not provide



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groundwater protection for facilities that are located in areas with high groundwater levels, areas underlain by materials with high primary or secondary hydraulic conductivity, or areas where the groundwater may become affected over time. In the same way, the existing regulations are not sufficient to provide groundwater quality protection for facilities that are located in areas subject to faulting or other geologic hazards (such as collapsible soils, subsidence, landslides, etc.) that could affect waste containment facilities.

It is also noted that Title 27 regulations require submittal of a ROWD that includes the following information general information:

- (1) average daily volume of facility wastewater and volume or weight of manure;
- (2) total animal population at the facility, and types of animals;
- (3) location and size of use or disposal fields and retention ponds, including animal capacity; and
- (4) animal capacity of the facility.

Significantly, Title 27 does not require that the ROWD address or otherwise consider site-specific geologic conditions (however, the Regional Board has the authority to request more information than is required by Title 27).

4.3 Comparison of Title 27 Confined Animal Facility Requirements with Other Waste Management Facilities Regulated by Title 27

In addition to regulating confined animal facilities, Title 27 also includes siting, design, construction, operation, post-closure, and monitoring requirements for Class II and Class III waste disposal facilities, which are intended to protect groundwater quality releases. These relatively comprehensive requirements are specifically designed to protect groundwater quality from releases from these facilities. Because there are similarities between animal wastes and some Class II and Class III wastes, comparison of Title 27 requirements for the different waste classifications provides insight into Title 27's ineffectiveness in protecting groundwater quality from releases from confined animal facilities.

Table 4-2 provides a comparative summary of the chemical composition of animal manure and sewage sludge. As shown in this table, nitrogen and salt concentrations for the two materials are similar; as described in Section 3, both of these compounds represent threats to water quality. The comparison of animal waste with sewage sludge is relevant because Title 27 classifies sewage sludge that has not been dewatered as a designated waste that must be disposed in a Class II waste management unit that complies with Title 27 requirements and has been approved by the RWQCB for containment of the waste. Dewatered sludge may be disposed in a Class III landfill as long as it satisfies non-hazardous waste requirements.

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TABLE 4-2 Comparison Of Typical Composition Of Sewage Sludge And Animal Manure			
CONSTITUENT	ANIMAL MANURE	SEWAGE SLUDGE	
		Range	Typical Value
Nitrogen (% dry weight)	1.7 – 7.8	<0.1 – 17.6	3.0
Total phosphorus (% dry weight)	0.3 – 2.3	<0.1 – 14.3	1.5
Total sulfur (% dry weight)	0.26 – 0.68	0.6 – 1.5	1.0
Calcium (% dry weight)	0.3 – 8.1	0.1 – 25	4.0
Magnesium (% dry weight)	0.29 – 0.63	0.03 – 2.0	0.4
Potassium (% dry weight)	0.8 – 4.8	0.02 – 2.6	0.3
Sodium (% dry weight)	0.07 – 0.85	0.01 – 3.1	NR
Aluminum (% dry weight)	0.03 – 0.09	0.1 – 13.5	0.5
Iron (% dry weight)	0.02 – 0.13	<0.1 – 15.3	1.7
Zinc (mg/kg dry weight)	56 – 215	101-27,800	1200
Copper (mg/kg dry weight)	16 – 105	6.8 – 3120	750
Manganese (mg/kg dry weight)	23 – 333	18 – 7,100	250
Boron (mg/kg dry weight)	20 – 143	4 – 757	25
Molybdenum (mg/kg dry weight)	2 – 14	2 – 976	10
Cobalt (mg/kg dry weight)	1	1 – 18	10
Arsenic (mg/kg dry weight)	12	0.3 – 316	10
Barium (mg/kg dry weight)	26	21 – 8,980	NR
NOTES: 1. Data from Commission on Geosciences, Environment, and Resources (1996), Chapter 2. 2. NR – Value not reported.			

Table 4-3 provides a summary that compares water quality protection requirements for confined animal facilities, Class II waste management units, and Class III waste management units (Appendix A contains the full text of Title 27 requirements for Class II waste management units, Class III waste management units, and confined animal facilities). As shown in this table, the confined animal facility requirements provide very limited controls designed for groundwater protection compared to the Class II and Class III requirements.

Table 4-3 also indicates that in contrast with confined animal facility requirements, Title 27 requires the evaluation of site-specific geologic, hydrogeologic, and seismologic characteristics for Class II and Class III units. Because a principal objective of Title 27 is to ensure protection of state surface and groundwater, this discrepancy supports the observation that Title 27 requirements for confined animal facilities do not address those site-specific factors important to groundwater protection. Consequently, it follows that the Title 27 requirements for confined animal facilities are less protective of groundwater than the Title 27 regulations for landfills and surface impoundments that may contain similar wastes.



TABLE 4-3
Comparison Of Title 27 Siting, Design, Construction, And Monitoring Requirements For Class II, Class III,
And Confined Animal Facilities

COMPONENT	CLASS II FACILITY	CLASS III FACILITY	CONFINED ANIMAL FACILITY
General Construction Criteria	<p>1. Class II waste management units (Class II "Units") shall be designed and constructed to prevent migration of wastes from the Units to adjacent geologic materials, ground water, or surface water, during disposal operations, closure, and the post closure maintenance period. Class II and Class III MSW landfills are also subject to any applicable waste containment system design requirements of SWRCB Resolution No. 93-62 to the extent that such requirements are more stringent than those applicable to a non-MSW Class II or Class III landfill under this subdivision.</p> <p>2. Each Class II Unit shall be designed and constructed for the containment of the specific wastes which will be discharged.</p> <p>3. For the purposes of this paragraph, the words "new" and "existing" have the same meaning as described in §20080(d). New landfills, waste piles, and surface impoundments shall comply with the requirements of this article. Existing waste piles and surface impoundments shall be fitted with liners and leachate collection and removal systems as described in §20330 and §20340 as feasible. Existing landfills and waste piles shall have interim cover as described in §20705. Existing landfills, waste piles, and surface impoundments shall be fitted with subsurface barriers as described in §20360 as needed and feasible, and shall have precipitation and drainage control facilities as described in §20365. Existing surface impoundments shall comply with §20375. New and existing land treatment units shall comply with §20377. All existing Units shall comply with the seismic design criteria in Section 20370.</p>	<p>1. Class II waste management units (Class II "Units") shall be designed and constructed to prevent migration of wastes from the Units to adjacent geologic materials, ground water, or surface water, during disposal operations, closure, and the post closure maintenance period. Class II and Class III MSW landfills are also subject to any applicable waste containment system design requirements of SWRCB Resolution No. 93-62 to the extent that such requirements are more stringent than those applicable to a non-MSW Class II or Class III landfill under this subdivision.</p> <p>2. Class III landfills shall have containment structures which are capable of preventing degradation of waters of the state as a result of waste discharges to the landfills if site characteristics are inadequate.</p> <p>3. For the purposes of this paragraph, the words "new" and "existing" have the same meaning as described in §20080(d). New landfills, waste piles, and surface impoundments shall comply with the requirements of this article. Existing waste piles and surface impoundments shall be fitted with liners and leachate collection and removal systems as described in §20330 and §20340 as feasible. Existing landfills and waste piles shall have interim cover as described in §20705. Existing landfills, waste piles, and surface impoundments shall be fitted with subsurface barriers as described in §20360 as needed and feasible, and shall have precipitation and drainage control facilities as described in §20365. Existing surface impoundments shall comply with §20375. New and existing land treatment units shall comply with §20377. All existing Units shall comply with the seismic design criteria in Section 20370.</p>	No General Construction Criteria

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TABLE 4-3
Comparison Of Title 27 Siting, Design, Construction, And Monitoring Requirements For Class II, Class III,
And Confined Animal Facilities

COMPONENT	CLASS II FACILITY	CLASS III FACILITY	CONFINED ANIMAL FACILITY
General Construction Criteria (Con't)	<p>4. Containment structures shall be designed by, and construction shall be supervised and certified by, a registered civil engineer or a certified engineering geologist. Units shall receive a final inspection and approval of the construction by RWQCB or SWRCB staff before use of the Unit commences.</p> <p>5. The discharger shall maintain the integrity of containment structures in spite of normal excavation or fire control work; nevertheless, for fire control work, the discharger can damage containment structures to the extent necessary to control the fire, so long as the discharger promptly repairs such damage after extinguishing the fire. Excavations made as part of discharge operations shall not result in removal of any portion of a containment structure.</p> <p>6. Stability Analysis—For any portions of the Unit's containment system installed after July 18, 1997, for which the RWQCB has not approved a slope and foundation stability report on or before that date, the discharger shall meet the requirements of §21750(f)(5).</p>	<p>4. Containment structures shall be designed by, and construction shall be supervised and certified by, a registered civil engineer or a certified engineering geologist. Units shall receive a final inspection and approval of the construction by RWQCB or SWRCB staff before use of the Unit commences.</p> <p>5. The discharger shall maintain the integrity of containment structures in spite of normal excavation or fire control work; nevertheless, for fire control work, the discharger can damage containment structures to the extent necessary to control the fire, so long as the discharger promptly repairs such damage after extinguishing the fire. Excavations made as part of discharge operations shall not result in removal of any portion of a containment structure.</p> <p>6. Stability Analysis—For any portions of the Unit's containment system installed after July 18, 1997, for which the RWQCB has not approved a slope and foundation stability report on or before that date, the discharger shall meet the requirements of §21750(f)(5).</p>	No General Construction Criteria
General Classification and Siting Criteria	<p>1. Waste management units shall be classified according to their ability to contain wastes. Containment shall be determined by geology, hydrology, topography, climatology, and other factors relating to the ability of the Unit to protect water quality.</p> <p>2. Class II waste management units shall be located where site characteristics and containment structures isolate waste from waters of the state.</p>	<p>1. Waste management units shall be classified according to their ability to contain wastes. Containment shall be determined by geology, hydrology, topography, climatology, and other factors relating to the ability of the Unit to protect water quality.</p> <p>2. Class III landfills shall be located where site characteristics provide adequate separation between nonhazardous solid waste and waters of the state.</p>	No general classification and siting criteria. No isolation or separation between wastes and waters of the state.
Separation from Groundwater	All new landfills, waste piles, and surface impoundments shall be sited, designed, constructed, and operated to ensure that wastes will be a minimum of five feet (5 ft.) above the highest anticipated elevation of underlying groundwater.	All new landfills, waste piles, and surface impoundments shall be sited, designed, constructed, and operated to ensure that wastes will be a minimum of five feet (5 ft.) above the highest anticipated elevation of underlying ground water.	No groundwater separation requirements are included in Title 27. (However, the 1995 Basin Plan for the Tulare Lake Basin required new retention ponds be sited, designed, constructed, and operated to ensure that the invert of the pond will be at least five feet above the highest anticipated elevation of groundwater.)



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TABLE 4-3
Comparison Of Title 27 Siting, Design, Construction, And Monitoring Requirements For Class II, Class III,
And Confined Animal Facilities

COMPONENT	CLASS II FACILITY	CLASS III FACILITY	CONFINED ANIMAL FACILITY
Foundation Requirements	All engineered structures (including, but not limited to, containment structures) constituting any portion of a Unit shall have a foundation or base capable of providing support for the structures, and capable of withstanding hydraulic pressure gradients to prevent failure due to settlement, compression, or uplift and all effects of ground motions resulting from at least the maximum credible earthquake.	All engineered structures (including, but not limited to, containment structures) constituting any portion of a Unit shall have a foundation or base capable of providing support for the structures, and capable of withstanding hydraulic pressure gradients to prevent failure due to settlement, compression, or uplift and all effects of ground motions resulting from at least the maximum probable earthquake.	No foundation requirements.
Geologic Setting	New and existing Class II landfills or waste piles shall be immediately underlain by natural geologic materials which have a hydraulic conductivity of not more than 1×10^{-6} cm/sec (i.e., 1 foot/year) and which are of sufficient thickness to prevent vertical movement of fluid, including waste and leachate, from Units to waters of the state for as long as wastes in such units pose a threat to water quality. Class II units shall not be located where areas of primary (porous) or secondary (rock opening) hydraulic conductivity greater than 1×10^{-6} cm/sec (i.e., 1 foot/year) could impair the competence of natural geologic materials to act as a barrier to vertical fluid movement.	New Class III landfills shall be sited where soil characteristics, distance from waste to ground water, and other factors will ensure no impairment of beneficial uses of surface water or of ground water beneath or adjacent to the landfill. Factors that shall be evaluated include: size of the landfill; hydraulic conductivity and transmissivity of underlying soils; depth to ground water and variations in depth to ground water; background quality of ground water; current and anticipated use of the ground water; and annual precipitation.	No geologic setting requirements.
Cutoff Walls	Cutoff walls are required at Class II Units where there is potential for lateral movement of fluid, including waste or leachate, and the hydraulic conductivity of natural geologic materials is used for waste containment in lieu of a liner.	Cutoff walls shall be installed at Class III landfills as required by the RWQCB.	No cutoff wall requirements.
Liner Requirements	A liner system with a hydraulic conductivity of not more than 1×10^{-6} cm/sec (e.g., 1 foot/year) shall be used for landfills and waste piles when natural geologic materials do not satisfy the geologic siting requirements. Surface impoundments may be required to have a single or a double liner system.	Where site characteristics alone do not ensure protection of the quality of ground water or surface water, Class III landfills shall be required to have a single clay liner with hydraulic conductivity of 1×10^{-6} cm/sec or less.	Must contain at least ten percent clay and no more than ten percent gravel.
Ground Rupture	New Class II Units and expansions of existing Class II units shall have a 200-foot setback from any known Holocene fault. Other units can be located within 200 feet of a known Holocene fault, provided the RWQCB finds that the Unit's containment structures are capable of withstanding ground accelerations associated with the maximum credible earthquake.	New Class III and expansions of existing Class II-2 landfills shall not be located on a known Holocene fault. However, existing landfills assigned a Class II-2 designation under previous versions of the SWRCB regulations may be located on a known Holocene fault, provided that the Unit's containment structures are capable of withstanding ground accelerations associated with the maximum probable earthquake.	No setback requirements.

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TABLE 4-3
Comparison Of Title 27 Siting, Design, Construction, And Monitoring Requirements For Class II, Class III,
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COMPONENT	CLASS II FACILITY	CLASS III FACILITY	CONFINED ANIMAL FACILITY
Rapid Geologic Change	New and existing Class II Units can be located within areas of potential rapid geologic change only if the RWQCB finds that the Unit's containment structures are designed, constructed, and maintained to preclude containment failure. MSW landfills are also subject to any more-stringent unstable area siting requirements referenced in SWRCB Resolution No. 93-62.	New Class III and unclassified existing Class II-2 landfills can be located within areas of potential rapid geologic change only if the RWQCB finds that the Unit's containment structures are designed, constructed, and maintained to preclude failure. MSW landfills are also subject to any more-stringent unstable area siting requirements referenced in SWRCB Resolution No. 93-62.	No location restrictions.
Material Properties	<p>1. Materials used in containment structures shall have appropriate chemical and physical properties to ensure that such structures do not fail to contain waste because of pressure gradients (including hydraulic head and external hydrogeologic forces), physical contact with the waste or leachate, chemical reactions with soil and rock, climatic conditions, the stress of installation, or because of the stress of daily operation.</p> <p>2. Earthen materials used in containment structures other than cutoff walls and grout curtains shall consist of a mixture of clay and other suitable fine grained soils which have the following characteristics, and which, in combination, can be compacted to attain the required hydraulic conductivity when installed. Liners made of such materials are referred to as "clay liners" in this subchapter.</p> <p>(1) At least 30 percent of the material, by weight, shall pass a No. 200 U.S. Standard sieve.</p> <p>(2) The materials shall be fine grained soils with a significant clay content and without organic matter, and which is a clayey sand, clay, sandy or silty clay, or sandy clay under a soil classification system having industry-wide use.</p>	<p>1. Materials used in containment structures shall have appropriate chemical and physical properties to ensure that such structures do not fail to contain waste because of pressure gradients (including hydraulic head and external hydrogeologic forces), physical contact with the waste or leachate, chemical reactions with soil and rock, climatic conditions, the stress of installation, or because of the stress of daily operation.</p> <p>2. Earthen materials used in containment structures other than cutoff walls and grout curtains shall consist of a mixture of clay and other suitable fine grained soils which have the following characteristics, and which, in combination, can be compacted to attain the required hydraulic conductivity when installed. Liners made of such materials are referred to as "clay liners" in this subchapter.</p> <p>(1) At least 30 percent of the material, by weight, shall pass a No. 200 U.S. Standard sieve.</p> <p>(2) The materials shall be fine grained soils with a significant clay content and without organic matter, and which is a clayey sand, clay, sandy or silty clay, or sandy clay under a soil classification system having industry-wide use.</p>	Must contain at least ten percent clay and no more than ten percent gravel.
Construction Quality Assurance (CQA)	After July 18, 1997, the RWQCB shall require construction for all liner systems and final cover systems to be carried out in accordance with a CQA plan certified by an appropriately registered professional to satisfy the requirements of §20324. If the RWQCB finds that any construction of the liner system or final cover system was undertaken in the absence of a CQA plan that satisfies the requirements of §20324, the RWQCB shall require the discharger to undertake any corrective construction needed to achieve such compliance.	After July 18, 1997, the RWQCB shall require construction for all liner systems and final cover systems to be carried out in accordance with a CQA plan certified by an appropriately registered professional to satisfy the requirements of §20324. If the RWQCB finds that any construction of the liner system or final cover system was undertaken in the absence of a CQA plan that satisfies the requirements of §20324, the RWQCB shall require the discharger to undertake any corrective construction needed to achieve such compliance.	No CQA requirements.



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TABLE 4-3 Comparison Of Title 27 Siting, Design, Construction, And Monitoring Requirements For Class II, Class III, And Confined Animal Facilities			
COMPONENT	CLASS II FACILITY	CLASS III FACILITY	CONFINED ANIMAL FACILITY
Seismic Design	Class II Units shall be designed to withstand the maximum credible earthquake (MCE) without damage to the foundation or to the structures which control leachate, surface drainage, or erosion, or gas.	Class III Units shall be designed to withstand the maximum probable earthquake (MPE) without damage to the foundation or to the structures which control leachate, surface drainage, or erosion, or gas.	No seismic design requirements.
Groundwater Monitoring	The RWQCB shall specify in the WDRs the specific type or types of monitoring programs required and the specific elements of each monitoring and response program. For each Unit, the RWQCB shall require one or more of the programs that is appropriate for the prevailing state of containment at the Unit, and shall specify the circumstances under which each of the programs will be required. In deciding whether to require the discharger to be prepared to institute a particular program, the RWQCB shall consider the potential adverse effects on human health or the environment that might occur before final administrative action on an amended report of waste discharge to incorporate such a program could be taken.	The RWQCB shall specify in the WDRs the specific type or types of monitoring programs required and the specific elements of each monitoring and response program. For each Unit, the RWQCB shall require one or more of the programs that is appropriate for the prevailing state of containment at the Unit, and shall specify the circumstances under which each of the programs will be required. In deciding whether to require the discharger to be prepared to institute a particular program, the RWQCB shall consider the potential adverse effects on human health or the environment that might occur before final administrative action on an amended report of waste discharge to incorporate such a program could be taken.	No specific monitoring requirements.
Water Quality Protection Standard	For each Unit, the RWQCB shall establish a water quality protection standard (Water Standard) in the WDRs. This Water Standard shall consist of the list of constituents of concern (under §20395), the concentration limits (under §20400), and the Point of Compliance and all Monitoring Points (under §20405). This Water Standard shall apply during the active life of the Unit, the closure period, the post closure maintenance period, and during any compliance period.	For each Unit, the RWQCB shall establish a water quality protection standard (Water Standard) in the WDRs. This Water Standard shall consist of the list of constituents of concern (under §20395), the concentration limits (under §20400), and the Point of Compliance and all Monitoring Points (under §20405). This Water Standard shall apply during the active life of the Unit, the closure period, the post closure maintenance period, and during any compliance period.	Not water quality protection standard required.
ROWD Requirements	Dischargers shall provide in the report of waste discharge an analysis describing how the ground and surface water could affect the Unit and how the Unit, including how any waste, if it escapes from the Unit, could affect the beneficial uses of ground water bodies (including, but not limited to, any aquifers underlying the facility) and surface water bodies. The RWQCB shall use this information to determine the suitability of the Unit with respect to ground water protection and avoidance of geologic hazards and to demonstrate that the Unit meets the classification criteria for the facility.	Dischargers shall provide in the report of waste discharge an analysis describing how the ground and surface water could affect the Unit and how the Unit, including how any waste, if it escapes from the Unit, could affect the beneficial uses of ground water bodies (including, but not limited to, any aquifers underlying the facility) and surface water bodies. The RWQCB shall use this information to determine the suitability of the Unit with respect to ground water protection and avoidance of geologic hazards and to demonstrate that the Unit meets the classification criteria for the facility.	Limited specific requirements that do not consider geologic and hydrogeologic conditions.

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COMPONENT	CLASS II FACILITY	CLASS III FACILITY	CONFINED ANIMAL FACILITY
Design Plans	As part of the report of waste discharge (“ROWD”, including any such report integrated into a Joint Technical Document, pursuant to §21585), dischargers who own or operate classified waste management units (Units) shall submit, for each such Unit, detailed preliminary and (later, after completion) as built plans, specifications, and descriptions for all liners (under §20330) and other containment structures (<i>e.g., final cover, under §21090</i>), leachate collection and removal system components (under §20340), leak detection system components [under §20415(b-d)], precipitation and drainage control facilities (under §20365), and interim covers installed or to be installed or used (under §20705). In addition, the ROWD shall contain a description of, and location data for, ancillary facilities including roads, waste handling areas, buildings, and equipment cleaning facilities, only insofar as the location and operation of these ancillary facilities could have an effect upon water quality.	As part of the report of waste discharge (“ROWD”, including any such report integrated into a Joint Technical Document, pursuant to §21585), dischargers who own or operate classified waste management units (Units) shall submit, for each such Unit, detailed preliminary and (later, after completion) as built plans, specifications, and descriptions for all liners (under §20330) and other containment structures (<i>e.g., final cover, under §21090</i>), leachate collection and removal system components (under §20340), leak detection system components [under §20415(b-d)], precipitation and drainage control facilities (under §20365), and interim covers installed or to be installed or used (under §20705). In addition, the ROWD shall contain a description of, and location data for, ancillary facilities including roads, waste handling areas, buildings, and equipment cleaning facilities, only insofar as the location and operation of these ancillary facilities could have an effect upon water quality.	No design plan requirements.
Monitoring System Plans and Rationale	Dischargers shall submit detailed plans and equipment specifications for compliance with the ground water and unsaturated zone monitoring requirements of Article 1, Subchapter 3, Chapter 3, Subdivision 1 of this division (§20380 et seq.). Dischargers shall provide a technical report which includes rationale for the spatial distribution of ground water and unsaturated zone monitoring facilities, [<i>e.g., the location and design of Monitoring Points and Background Monitoring Points for each monitored medium under §20415(b-e)</i>], and for the selection of other monitoring equipment.	Dischargers shall submit detailed plans and equipment specifications for compliance with the ground water and unsaturated zone monitoring requirements of Article 1, Subchapter 3, Chapter 3, Subdivision 1 of this division (§20380 et seq.). Dischargers shall provide a technical report which includes rationale for the spatial distribution of ground water and unsaturated zone monitoring facilities, [<i>e.g., the location and design of Monitoring Points and Background Monitoring Points for each monitored medium under §20415(b-e)</i>], and for the selection of other monitoring equipment.	No specific monitoring system requirements.



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Section 5

Groundwater Quality Below Confined Animal Facilities

Data reviewed for this evaluation shows that dairies and other confined animal facilities can adversely affect groundwater quality by increasing levels of nitrogen compounds (typically nitrates, nitrites, and ammonia), TDS, and other potential contaminants above regulatory limits. This data is summarized below and includes information from various technical publications, groundwater studies conducted in the Central Valley, and site-specific data for different dairies from CVRWQCB files.

It is important to note there are limitations associated with the CVRWQCB data, including: the data is not sufficient to support a statistically valid conclusion that confined animal facilities have impacted groundwater quality at or adjacent to a particular facility; the data is not sufficient to support a conclusion regarding the precise source of groundwater impacts at a particular facility; there is frequently no data regarding facility construction with respect to the Title 27 minimum standards (e.g. the clay content of the pond bottoms are commonly uncertain or not known); and operations and maintenance practices for the different facilities are frequently unknown. These limitations notwithstanding, the data is sufficient to draw broad conclusions that may be compared with information from relevant published studies.

5.1 Groundwater Quality Data from Central Valley Confined Animal Facilities

5.1.1 CVRWQCB Confined Animal Facility Database

As part of this project, the CVRWQCB provided a database summarizing analytical data from monitoring wells at ten different dairies located in Madera, Fresno, Kings, and Tulare Counties. This data is included in Appendix C. The monitoring wells sampled at these facilities were specified as located upgradient of site activities and facilities or downgradient of corrals, wastewater retention pond(s), croplands, or the facilities in general. Table 5-1 provides a general summary of this data using nitrate and TDS as indicators of possible impacts from the different facilities. As shown in this table:

- **Corrals.** Average upgradient nitrate concentrations were lower than average corral downgradient nitrate concentrations at three of the five dairies where data was available for comparison. Upgradient nitrate concentrations were higher than downgradient nitrate concentrations at the other two facilities.
- **Ponds.** Average upgradient nitrate concentrations were lower than average pond downgradient nitrate concentrations at three of the five dairies.
- **Croplands.** Average upgradient nitrate concentrations were lower than all average downgradient cropland nitrate-monitoring locations.



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- **Multiple locations.** Average upgradient nitrate concentrations were lower than average downgradient nitrate concentrations in wells that monitor multiple locations at two of the five dairies (“other” locations in Table 5-1).

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TABLE 5-1
Summary Of Nitrate And TDS Groundwater Data From CVRWQCB Database

SITE	AVERAGE UPGRADIENT NITRATE CONCENTRATION (mg/L)	AVERAGE DOWNGRADIENT NITRATE CONCENTRATION (mg/L)				AVERAGE UPGRADIENT TDS CONCENTRATION (mg/L)	AVERAGE DOWNGRADIENT TDS CONCENTRATION (mg/L)			
		Corrals	Ponds	Cropland	Other		Corrals	Ponds	Cropland	Other
Tri-iest Dairy, Madera County	ND	ND	42	43	53	ND	ND	730	690	925
VLOT Heifer Ranch & Dairy, Madera County	12	78	27	ND	ND	440	740	970	ND	ND
Zonneveld Dairies, Fresno County	71	18	22	182	ND	353	440	757	673	ND
Freitas View Holsteins, Fresno County	145	ND	205	530	96	760	ND	880	1,650	650
White River Dairy, Kings County	22	1	ND	139	13	23,000	24,000	ND	18,000	26,000
Joe Parreira Dairy, Kings County	ND	ND	22	ND	8	ND	ND	27,729	ND	11,189
Highstreet Dairy, Tulare County	70	ND	15	150	108	447	ND	1,093	620	733
Artesia Dairy, Tulare County	15	46	ND	ND	<40	1,100	1,800	ND	ND	2,333
Elkhorn Dairy, Tulare County	21	95	87	ND	76	167	985	892	ND	536
Triple H Dairy, Tulare County	ND	110	<40	89	120	ND	690	2,100	670	690
AVERAGES	51	58	60	189	68	3,752	4,776	4,394	3,717	5,382

NOTES:

1. Data summarized from CVRWQCB database - see Appendix C.
2. "Other" refers to wells identified as downgradient from two or more facilities or from wells located where the hydraulic gradient is uncertain.
3. Corrals at VLOT Heifer Ranch & Dairy had not been used at the time groundwater samples were collected.
4. Average upgradient nitrate concentration from Elkhorn Dairy is skewed by one 100 mg/L nitrate concentration out of 7 samples.
5. Average upgradient TDS concentration from Elkhorn Dairy is skewed by one 1,000 mg/L TDS concentration out of 5 samples.
6. ND - No Data Reported.



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Total dissolved solids data is somewhat more definitive than the nitrate results and indicates that:

- **Corrals and ponds.** Average upgradient TDS concentrations were lower than average downgradient TDS concentrations for all corral and pond monitoring locations where data is available.
- **Croplands.** Average upgradient TDS concentrations were lower than average downgradient TDS concentrations for three of four cropland-monitoring locations.
- **Multiple locations.** Average upgradient TDS concentrations were lower than average downgradient TDS concentrations for four of five locations that monitor multiple facilities.

Taken as a whole, the CVRWQCB database indicates that groundwater has been affected locally by releases from several of the facilities for which data is available. The data also suggests that manure applications to croplands may have a significant impact on groundwater quality. However, the database provides little specific information regarding depth to groundwater, well screen intervals, specific well locations with respect to the different facilities, surrounding land uses, or subsurface conditions. As a result, the data by itself cannot be used to identify the constituent source areas for individual monitoring wells.

Perhaps the most significant data with respect to this report is the results that indicated groundwater immediately downgradient of the retention ponds at the Highstreet Dairy and Elkhorn Dairy have been affected by nitrogen compounds and salts. According to the pond monitoring data in Appendix C, the ponds at the Highstreet Dairy and the Elkhorn Dairy have been certified as having at least ten percent clay and no more than ten percent gravel (as specified in Title 27) (CVRWQCB 2003).

5.1.2 Harter et al. Evaluation of Shallow Groundwater Quality on Dairy Farms with Irrigated Forage Crops

Harter et al. completed a seven-year study of dairies in the Central Valley to assess nitrate and salt leaching to shallow groundwater in a relatively vulnerable hydrogeologic region and to quantify the impact from individual sources on dairies (Harter et al. 2002). For the purposes of this study, the array of potential point and non-point sources was divided into three major source areas representing farm management units, including: (1) manure water lagoons (ponds); (2) feedlot or exercise yards, dry manure, and feed storage areas (corrals); and (3) manure irrigated forage fields (fields).

An extensive shallow groundwater-monitoring network of 44 wells was installed in five representative dairy operations in the northeastern San Joaquin Valley, and water quality was observed over a four-year period. Results from this study are summarized in Table 5-2 and show measurable increases in specific conductivity (a measure of salinity), total nitrogen, and Total Kjeldahl Nitrogen (TKN) in wells that monitored the various facility waste management units as compared with upgradient groundwater samples. Particular conclusions of the study included the following:

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- The range of observed nitrate-N and salinity (EC) levels were subject to large spatial and temporal variability, although the range of observed nitrate-N and salinity levels were similar at all five dairies.
- Average shallow groundwater nitrate-N concentrations within the dairies were 64 mg/L, compared to 24 mg/L in shallow wells immediately upgradient of these dairies. Average EC levels were about 1,900 uS/cm within the dairies and about 800 uS/cm immediately upgradient.
- Within the dairies, nitrate-N levels did not significantly vary across dairy management units. However, EC levels were significantly higher in corral and pond areas than in field areas, thereby indicating leaching from those management units.
- Pond leaching was further inferred from the presence of reduced nitrogen in three of the four wells located immediately downgradient of pond berms.

Based on these results, Harter et al. concluded that data collected during the seven-year study confirmed shallow groundwater quality below the dairies with irrigated forage crops is degraded by high levels of nitrate and salts, although the exact location and extent of the source area of individual monitoring wells is difficult to determine in practice (Harter et al. 2002).

TABLE 5-2 Summary Of Shallow Groundwater Analytical Results From Harter et al. (2002) Study							
MANAGEMENT UNIT	NO. OF WELLS	SPECIFIC CONDUCTIVITY (uS/cm)		TOTAL N (mg/L)		TKN (mg/L)	
		Mean	Coefficient of Variation	Mean	Coefficient of Variation	Mean	Coefficient of Variation
Upgradient	5	810.0	0.45	23.30	0.59	2.70	0.17
Upper Field	8	1593.0	0.47	74.70	0.56	3.50	0.24
Corral	10	2262.2	0.31	65.00	0.46	3.30	0.28
Pond	2	2497.3	0.01	55.40	0.44	36.80	0.15
Multiple	9	1991.9	0.26	71.30	0.51	4.50	0.55
Lower Field	10	1537.2	0.38	51.30	0.51	2.50	0.25
Corral and Pond	12	2301.4	0.28	63.40	0.45	8.90	1.47
Upper and Lower Fields	18	1562.0	0.41	61.70	0.57	3.00	0.30

5.1.3 Los Banos Area Groundwater Study

In 2001, Boyle Engineering completed an evaluation of groundwater in the Los Banos area in part to assess whether existing land uses were significantly polluting or contaminating the groundwater. As part of the study, Boyle Engineering evaluated ten animal facilities and concluded that, "existing land uses, many at confined animal operations, are causing ongoing water quality degradation problems involving salts, nitrogen, and possibly other



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chemicals not yet measured” (Boyle Engineering 2001). Data used to support this conclusion is summarized in Table 5-3. Based on this data, Boyle recommended that each dairy be required to design and install an adequate groundwater-monitoring program, taking into account all animal holding areas, wastewater lagoons, and wastewater land application areas within the dairy property and on adjacent lands owned by others who allow dairy wastewater applications on their land. Boyle also recommended that existing dairy lagoons be evaluated to determine whether they have liners and whether the bottom of each lagoon (including the liner) is at least above the historic high groundwater level.

TABLE 5-3 Summary Of Boyle Engineering (2001) Conclusions Regarding Groundwater Impacts From Confined Animal Facility Operations				
FACILITY NAME	CONCLUDED TO IMPAIR GROUNDWATER QUALITY			
	Elevated TDS	High TDS	Elevated Nitrate	High Nitrate
Los Banos Abattior	---	Yes ¹	---	Yes ¹
O/L Dairy	Yes ¹	---	---	Yes ¹
Oliveira Dairy	Yes ¹	---	Yes ¹	---
Soares & Ramos Dairy	---	---	Yes ²	---
Vaz Dairy	---	Yes ^{1,2}	---	Yes ^{1,2}
Rondoni Dairy	---	Yes ^{1,2}	---	Yes ^{1,2}
Silva Dairy (abandoned)	---	Yes ²	---	Yes ²
Silview Dairy	Yes ²	Yes ¹	---	Yes ^{1,2}
Freitas Dairy	---	Yes ²	---	Yes ²
Wolfsen Feedlot	Yes ²	---	---	Yes ²
NOTES: 1. Based on on-site well(s) 2. Based on downstream well(s)				

5.1.4 Hilmar Study

The community of Hilmar, an intensively farmed area located approximately 20 miles northwest of the City of Merced, was identified in the late 1970s as having groundwater nitrate levels that exceeded state drinking-water standards. Studies were conducted by the CVRWQCB to determine the extent and likely sources of the high nitrate levels. The results were described in a 1987 report entitled *Hilmar Groundwater Study* (Lowry 1987). It was found that excessive nitrate levels were common in the Hilmar area groundwater and could be directly related to the application of animal wastes to cropland in many instances. (Commercial fertilizer use in vineyards and orchards in the area was also shown to contribute to excessive nitrate levels.) Estimates of nitrogen and salt loading rates from the various possible sources indicate that dairy wastes and fertilizers accounted for

approximately 85 percent of the total nitrogen load in the area, and that dairy wastes were the largest contributor to the total salt load.

5.1.5 Gil-Tex Dairy

In 1991, United States Testing Company completed a Monitoring and Reporting Program at the Gil-Tex Dairy, located in Turlock, California, that included soil borings, monitoring well installation, and the collection and analysis of groundwater samples from the monitoring wells. The United States Testing Company Report is included in Appendix D. The results of this program led to a number of conclusions, the most significant of which included the following:

- High levels of nitrates were detected in the surface soil and groundwater samples that were analyzed.
- The upgradient well had a nitrate level of 1,020 mg/L, which was significantly higher than the downgradient wells. For comparison, the state maximum contaminant level of nitrate is 45 mg/L. The upgradient well was located immediately adjacent to a holding pond, and the results indicated that it was influenced by the presence of the pond or possibly by an offsite source.
- The depth to groundwater was about 29 feet below the ground surface during drilling, and the site is underlain by an upper unit consisting of mixed silty sand (SM) and sandy silt (ML). The lower unit is dominated by clay sand (SC).
- As reported, laboratory testing indicated that the upper unit contained soil approximately 30 percent finer than the No. 200 sieve (silt and clay size). About 57 percent of the lower unit passed the No. 200 sieve.⁶

Based in part on these findings, the CVRWQCB issued Cleanup and Abatement Order (CAO) No. 98-717 (included in Appendix D) that found: "Analytical data in four ground water monitoring reports received for the period of November 1996 to September 1997 indicates that operation of the facility has resulted in groundwater degradation by nitrates" (Central Valley Regional Water Quality Control Board 1998). The CVRWQCB also concluded that the shallow groundwater at the dairy had been impacted by animal wastes and that the impacts were believed to be due to inadequate storage capacity of the holding pond.

5.1.6 Vaz Dairy

The Vaz Dairy, located in Los Banos, had 1,520 animal units in April 2000, including milk cows, dry cows, and calves. The dairy has approximately 90 acres of cropland for

⁶Because Atterberg limits data or hydrometer data for the soils are not available and because silt and clay particles are both reported to be finer than the No. 200 sieve, the classification of the fine-grained materials as silt, clay, or a combination of silt and clay is uncertain. Laboratory testing data was not included in the report and the location(s) of the sample(s) with respect to the retention pond is not known.

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wastewater application. According to the CVRWQCB March 25, 2001 *Regulatory Status Update for the Vaz Dairy* (included in Appendix E), data from monitoring wells at the Vaz Dairy indicates that animal wastes have impacted groundwater in the vicinity of the wastewater holding pond. The depth to groundwater in the area near the holding pond is reported to be approximately 15 to 20 feet below the ground surface, and a soil boring indicates that there are gravel layers in the underlying soil. Monitoring data reported by the Merced County Division of Environmental Health (included in Appendix E) indicates groundwater degradation from either the retention pond or the application field. Merced County Division of Environmental Health (2002) also notes that soil-boring data indicates that all soils to a depth of 12 feet below grade (about eight feet below the bottom of the lagoon) had a minimum of 19 percent clay with no gravel.

5.1.7 Rick Jones Dairy

In 1994, Kleinfelder installed three groundwater-monitoring wells to assess groundwater quality near a proposed settling pond and corral at the Rick Jones Dairy, located in Merced County. Site specific information is included in Appendix F. Soils encountered during installation of the wells consisted of silty sand and sandy silt, and groundwater was encountered at depths of approximately eight to ten feet below the ground surface. Samples collected after well installation indicated nitrate (as NO_3) concentrations that varied from approximately 10.3 mg/L to 93.0 mg/L. Ammonia and TKN were not detected. Monitoring data collected since then has indicated relatively high TDS and nitrate detections in all three of the monitoring wells (Kleinfelder 2003). TKN has periodically been detected in all three of the monitoring wells. These results suggest that groundwater may have been affected by dairy operations. Kleinfelder indicates that the wastewater lagoon liner met the requirement for ten percent minimum clay.

5.2 Groundwater Quality Information from Published Studies

Published studies regarding confined animal facility waste containment and groundwater quality were reviewed to address some of the limitations associated with the CVRWQCB data and to corroborate the conclusions that were drawn from the data with respect to the groundwater quality and the minimum standards included in Title 27. Principal conclusions from these studies and the application of these conclusions to the evaluation of Title 27 requirements are summarized below.

5.2.1 Nitrogen Load of Soil and Groundwater from Land Disposal of Dairy Manure

Adriano et al. (1971) completed a study that included the installation of 15 deep borings in the Chino-Corona dairy area, about midway between Los Angeles and Riverside. The tests included two control or undisturbed sites with no manure or irrigation water applied; six irrigated cropland sites used for the disposal of solid manure, liquid manure, or both; five irrigated pasture sites where wastes from milking operations were disposed; and two corral

sites where manure was generally scraped twice yearly and discharged to croplands or pastures. Soil samples from these borings were analyzed for ammonium-nitrogen, nitrite-nitrogen, and nitrate-nitrogen. At the same time, groundwater from shallow wells were analyzed for nitrate and total salt and these results were compared with analytical data from adjacent, relatively deeper domestic water supply wells.⁷

The results of the Adriano study indicated the average concentrations of ammonium-nitrogen in soil profiles under croplands, pastures, and corrals were considerably higher than in the control areas. Ammonium-nitrogen and nitrite-nitrogen were particularly high in the 0 ft to 2 ft depths below corrals. Nitrate-nitrogen concentrations for all areas were also well above the control samples, with the highest values being under corrals. Nitrate and total salt concentrations in groundwater from shallow wells were higher than in the deeper well waters and based on these results, Adriano et al. concluded “shallow wells near corrals and other heavily manured areas could be contaminated with NO_3^- . A real problem with NO_3^- can arise if the profile is sandy” (Adriano et al. 1971).⁸

5.2.2 Effects of Liquid Manure Storage Systems on Groundwater Quality Summary Report

The Minnesota Pollution Control Agency completed a report in 2001 that includes information from four different studies of confined animal facilities in Minnesota. Most of the studies were conducted in shallow groundwater underlying coarse-textured soils and included installing and sampling a number of temporary wells at open feedlots with no liquid manure storage, feedlots with liquid storage but no cohesive soil liner or other type of constructed liner (unlined basins), feedlots with liquid storage and compacted soil liners, and feedlots with liquid storage and concrete-lined basins. An additional study consisted of monitoring an open feedlot where an earthen manure storage basin was lined with a plastic, geosynthetic, bentonite clay liner in 1997.

The results of these studies indicated wide-ranging impacts at different sites, with evidence of shallow groundwater contamination downgradient of manure storage areas at each site (Minnesota Pollution Control Agency 2001). The downgradient distance in groundwater to which impacts were observed was less than 100 feet for concrete-lined systems, 200 to 300 feet for open lots and earthen-lined systems, and several hundred feet for unlined systems. Evidence of impacts included higher concentrations of ammonia-nitrogen, organic nitrogen, organic carbon, phosphorus, chloride, and potassium in downgradient versus upgradient wells. Monitoring at an open feedlot where a new, geosynthetic clay liner was constructed showed improvements in water quality after three years.

⁷ The data shown in Graph 4 of Adriano et al. (1971) indicate the shallow samples were collected from depths that ranged from about 40 to 60 feet below the ground surface. The depth of the deeper domestic supply wells ranged from about 150 feet to more than 400 feet below the ground surface.

⁸ Nitrate concentrations in the shallow wells varied from 62 mg/L to 930 mg/L and exceeded the drinking water standard of 45 mg/L in all wells. Nitrate concentrations in the deeper water supply wells varied from 6 mg/L to 43 mg/L and were less than the 45 mg/L drinking water standard.



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These results cannot be directly applied to the Title 27 percent clay minimum standard for retention ponds because specific soil property data was not included for the earthen lined and unlined ponds. However, the report indicates the earthen lined systems consisted of two feet of compacted cohesive soils. The fact that the soils were cohesive suggests some percentage of clay in the liner and tends to support the conclusion that the Title 27 ten percent clay requirement is not sufficient by itself to protect groundwater quality.

5.2.3 Dairy Facility Contributions to Groundwater Contamination

Arnold and Meister completed a study in 1999 that evaluated dairy facility contributions to groundwater contamination in New Mexico based on 313 groundwater samples collected from 26 monitoring wells around seven wastewater lagoons on seven dairies over a six-year period. Wastewater lagoons included clay-lined, cement-lined, and synthetic-lined facilities. The results of this study indicated that mean contaminant concentrations exceeded groundwater quality standards for nitrate, ammonia, chloride, and TDS at all dairies and all wells (Arnold and Meister 1999). In general, mean nitrate levels were significantly highest for clay-lined lagoons. Mean TKN, chloride, and TDS levels were slightly higher for clay linings than for cement or synthetic linings.

These results indicate that mean ammonia levels were significantly lowest for synthetic linings and that nitrate and TDS levels were slightly lower for synthetic linings than for cement and clay lagoon liners. The results also indicate among the three types of lining systems that were evaluated, clay linings are the least effective for reducing groundwater contamination. This conclusion is consistent with the Minnesota Pollution Control Agency (2001) findings and provides additional support for the conclusion that the Title 27 ten percent clay requirement is not sufficient by itself to protect groundwater quality. (Similar to the Minnesota Pollution Control Agency report, Arnold and Meister did not document the clay content of the earthen liners).

5.2.4 Measurement of Seepage from Earthen Waste Storage Structures

In 1999, Glanville et al. completed a study to assess seepage from earthen waste storage structures. As reported, soil samples collected downgradient from 11, 10-to-12-year-old lagoons in North Carolina indicated that five lagoons exhibited low seepage, while the remaining six were judged to have moderate or high seepage (Glanville et al. 1999). The results of the study also indicated that monitoring wells near two new swine lagoons constructed in deep sandy soils in North Carolina exhibited significant seepage after three to five years, as well as significant spatial variation of contaminants within the seepage plumes.

Based on study results, Glanville et al. concluded that seepage rates in fine-grained soils are typically lower than in coarse-grained materials, although this trend is not universal. However, the differences between loss rates for structures constructed in fine-grained soils compared to those where coarser-grained sediments are the dominant surficial geologic materials “further emphasizes the need for detailed siting, design, and construction

guidelines that recognize the differences in the performance potential of various soils and geologic materials” (Glanville et al. 1999). These results support the finding that the Title 27 minimum standards for confined animal facilities are not sufficient to protect groundwater because they do not require consideration of site-specific subsurface conditions in the siting, design, and operation of these facilities.

5.2.5 Evaluation of Impacts of Animal Waste Lagoons on Groundwater Quality

The North Carolina Department of Environment and Natural Resources (NCDENR) completed a study in 1998 of the impacts of ten swine facility and two dairy facility animal waste lagoons on groundwater quality. The purpose of the NCDENR study was to determine whether federal NRCS construction standards used by North Carolina regulatory agencies for lagoons provide adequate groundwater protection. The study considered geologic vulnerability to assess potential groundwater contamination and for the purposes of the study, vulnerable conditions were assumed to exist where (NCDENR 1998):

- Insufficient separation distance exists between the lagoon bottom and the seasonal high-water table.
- Coarse-grained soils and sediments are dominant above the first significant clay layer in the subsurface.
- Clay layers in the surficial aquifer are discontinuous and imbedded with coarse-grained material.

Five of the farms that were evaluated were considered “less vulnerable,” four were considered “moderately vulnerable,” and two were viewed as “vulnerable.”

Of the five less-vulnerable sites, none of the downgradient shallow monitoring wells indicated any seepage problems from the lagoons. Wells at three of the four moderately-vulnerable sites showed an increasing trend in concentrations of one or more lagoon seepage indicators, such as nitrates and chlorides. Wells at one of the two vulnerable sites showed lagoon seepage contamination from ammonia, potassium, and nitrates. Principal conclusions from the two dairies that were investigated included:

- **PRS Site.** According to the NCDENR study, the waste lagoon for this facility was reportedly constructed in accordance with NRCS standards. The unlined lagoon was excavated in “medium to fine textured” soils, and has been in operation for more than 20 years. Monitoring wells were located downgradient of the lagoon, with screened intervals that ranged from 19 to 22 feet below the ground surface. The water table below the facility varied from about 6 to 14 feet below the ground surface. A significant clay layer more than 15 feet thick was found in each of the downgradient monitoring wells. Based on this information, the PRS site was considered “less vulnerable.” No lagoon seepage was reported for this facility.



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- **Gaston Site.** The waste lagoon for this facility was excavated in “medium to fine textured” soils and was constructed so that it met the construction criteria defined in the NRCS standards. Wells were located downgradient of the lagoon and were installed in “medium textured” soils. Depths to the tops of the screens ranged from 3 to 5 feet below the ground surface and the water table below the facility ranged from about 7 to 9 feet below the ground surface. Based on this data, the Gaston site was considered “moderately vulnerable.” All three of the shallow downgradient wells showed some indication of lagoon seepage during the study.

Similar to Glanville et al. (1999), the NCDENR (1998) report highlights the importance of geologic conditions with respect to the protection of groundwater quality from releases from these facilities. The report also substantiates a conclusion that the Title 27 minimum standards for confined animal facilities are not sufficient to protect groundwater because they do require consideration of site-specific subsurface conditions in the siting, design, and operation of these facilities.

The NCDENR report findings are also important because the lagoons at both the PRS and Gaston sites were constructed to NRCS standards that are more stringent than the Title 27 minimum standard of ten percent clay. As described in Section 4.1.2, the NRCS standards require a minimum liner hydraulic conductivity of 1×10^{-6} cm/sec and assume that this value is assumed to decrease one order of magnitude (to 1×10^{-7} cm/sec) due to sealing (NRCS 1997). Despite construction to this more rigorous standard, the downgradient wells at the Gaston site showed evidence of lagoon seepage, thereby supporting a conclusion that the Title 27 minimum standard of ten percent clay is not sufficient to protect groundwater quality under vulnerable geologic conditions.

Section 6

Conclusions and Recommendations

6.1 Conclusions

Sections 22560 through 22565 of CCR Title 27 set forth minimum standards for the discharge of animal wastes and specify the information that should be submitted to the RWQCB in the form of a ROWD by a confined animal facility operator. The CVRWQCB, in turn, must rely on these minimum standards and the information included in the ROWD to issue WDRS that address the applicable Basin Plan requirements and implement the State's Antidegradation Policy. The purpose of this report was to evaluate the effectiveness of Title 27 of the CCR requirements intended to protect groundwater quality in the Central Valley from possible discharges from confined animal facilities.

Based on the data from Central Valley dairies and from the information included in published studies, it is reasonable to conclude that current Title 27 requirements are insufficient to prevent groundwater contamination from confined animal facilities, particularly in vulnerable geologic environments. Moreover, based on the limited information required by Title 27 to be included in a ROWD, it would be difficult for the CVRWQCB to reliably evaluate the nature and possible water quality consequences of animal waste discharges. Therefore, the CVRWQCB cannot implement the applicable Basin Plan and Antidegradation Policy requirements without requesting additional site-specific data (as described previously, Title 27 allows the Board to request additional information as necessary for its evaluations). Specific information and data that supports these conclusions include:

- **Central Valley Data.** Central Valley data (e.g., CVRWQCB file information; Boyle Engineering 2001; Lowry 1987) indicates animal wastes have affected groundwater quality at a number of Central Valley dairies. These findings are supported by the results of Harter et al.'s (2002) multi-year study of dairies in the Central Valley that show shallow groundwater quality below the dairies is degraded by high levels of nitrate and salts and by USGS data (Dubrovsky et al. 1998) that show median nitrate concentrations in shallow groundwater wells in the San Joaquin Valley have increased significantly since the 1950s, during which time the number of dairies and other confined-animal feedlots also increased greatly. Dubrovsky et al. (1998) identified nitrogen fertilizer and confined animal facilities as the source of these nitrate concentrations. Although there are limitations associated with the available data, taken as a whole, it indicates that groundwater in the Central Valley has been locally affected by releases from confined animal facilities. The data from published studies described in this report help overcome some of the limitations associated with the Central Valley-specific data.
- **Title 27 Operations Requirements.** Title 27 requires that manured areas must be managed to "minimize" infiltration of water into the underlying soils. These requirements do not set an appropriate, quantifiable standard and do not consider site-specific



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subsurface conditions. Therefore the above regulatory limits provide no assurance that groundwater will be free of infiltration from manured areas such as corrals. This conclusion is supported by the Harter et al. (2002) data that indicates specific conductivity values were significantly higher in corral and pond areas than in field areas, thereby indicating leaching from those management units. The conclusion is further corroborated by the results of Adriano et al. (1971) that show measurably higher average concentrations of ammonium-nitrogen in soil profiles under corrals compared with control areas. The results of these studies also documented increased nitrate and total salt concentrations in shallow groundwater compared with concentrations of these constituents in control wells.

- **Title 27 Retention Pond Design Requirements.** Current Title 27 requirements do not require low-hydraulic conductivity containment systems for waste storage ponds. Rather, Title 27 requires only that retention ponds be lined with, or underlain by, soils which contain at least ten percent clay and not more than ten percent gravel. The hydraulic conductivity of materials that meet this criteria conceivably could range from 10^{-6} cm/sec to as much as 10^{-3} cm/sec or greater (other factors being equal, each order of magnitude change in hydraulic conductivity can result in a ten-fold increase in seepage and contaminant loading). Consistent with this range, NRCS (1997) guidance indicates soils with less than 20 percent clay have high permeability that could allow unacceptably high seepage losses and recommends that retention ponds underlain by soils with less than 20 percent clay be lined because coarse-grained soils with less than 20 percent low-plasticity fines have the potential to allow rapid movement of contaminants to the groundwater. Based on these findings, there is no assurance that facilities meeting the Title 27 requirement of ten percent clay will be protective of groundwater. This conclusion is supported by data that indicates retention ponds at the Highstreet, Elkhorn, Vaz, Rick Jones, and possibly the Gil-Tex dairies meet the Title 27 requirement to contain at least ten percent clay and no more than ten percent gravel. CVRWQCB data indicates animal wastes have affected the groundwater below these facilities. In addition, data from a published study (NCDENR 1998) documents groundwater pollution has occurred from animal waste retention ponds constructed in vulnerable geologic environments to NRCS standards that are more stringent than the current Title 27 requirements.
- **Site Specific Conditions.** The effectiveness of the existing Title 27 in protecting groundwater quality is partially dependent on the nature and characteristics of subsurface conditions. However, Title 27 does not require consideration of subsurface geologic conditions or the depth to groundwater in the siting, design, construction, or operation of confined animal facilities or waste management systems. For cases where the facility is located in a stable area, is underlain by a sufficient and consistent thickness of fine-grained soils, and groundwater occurs at depth, the potential for groundwater degradation may be low. Conversely, groundwater could be degraded rapidly for a facility underlain by coarse-grained soils, fractured bedrock, and/or shallow

groundwater. This conclusion from published studies (e.g. Glanville et al. 1999 and NCDENR 1998) demonstrates that groundwater contamination has resulted from confined animal facilities that were constructed in conformance with the NRCS standards

- **Title 27 Information Requirements.** Title 27 regulations require submittal of a ROWD that includes general information regarding the average daily volume of facility wastewater and volume or weight of manure; total animal population at the facility and types of animals; the location and size of use or disposal fields and retention ponds; and the animal capacity of the facility. However, Title 27 does not require that the ROWD address or otherwise consider site-specific geologic conditions. In absence of this information, the RWQCB cannot use the ROWD to reliably evaluate the nature and possible water quality consequences of the facility waste discharges. Therefore, without making a request for additional site-specific information, the RWQCB cannot dependably evaluate the nature and possible water quality consequences of animal waste discharges.

6.2 Data Limitations and Recommendations for Further Research

On a quantitative basis, little is known about direct groundwater quality impacts from many elements of confined animal facility manure management practices in the Central Valley because relatively few comprehensive groundwater research projects have been completed and few facilities have groundwater-monitoring programs designed to provide definitive data on the subject (Harter et al. 2002). Moreover, the groundwater-monitoring data from those facilities with monitoring requirements is often difficult to interpret because there are few wells with little monitoring data and the upgradient groundwater quality may have been affected by adjacent agricultural operations. Additionally, in many cases, it has not been determined if the facility is operating in compliance with the Title 27 requirements and it is difficult to identify one possible source from another.

Recommendations for addressing these data deficiencies include, but are not limited to, the:

- Development of a geographic database that includes confined animal facility locations and is linked to monitoring data or information that indicates the presence or absence of associated groundwater quality impacts. Information from this database, overlain on geologic maps, groundwater maps, and land use maps may be used to identify facilities, or general areas in the Central Valley, that pose a particular risk based on subsurface geologic conditions and depth to groundwater.
- Completion of laboratory and field analysis of the attenuation and absorption of primary contaminant constituents such as salts and nitrogen traveling through differing types of soil strata typically represented in the Central Valley.
- Completion of additional site specific studies of the unsaturated zone beneath retention ponds. Specific knowledge about the design, construction and operational practices of



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the subject ponds should be incorporated into the research to quantify the hydraulic conductivity of the pond and resulting effectiveness of the self sealing theorems on which current regulations were constructed.

- Completion of studies relative to animal waste related pathogen, hormone, pesticide and antibiotic transmission and their effect on groundwater.

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